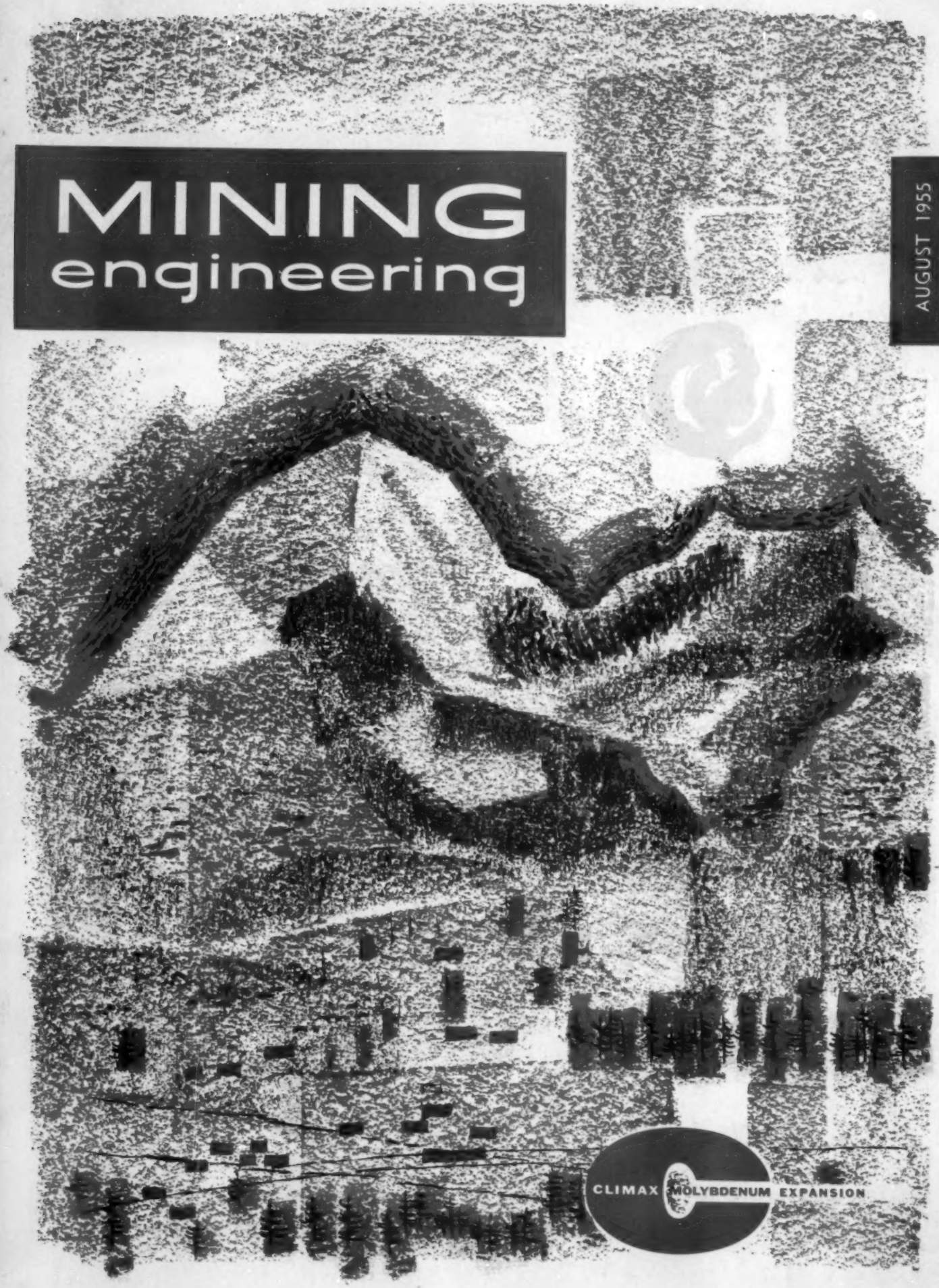
MINING engineering

AUGUST 1955



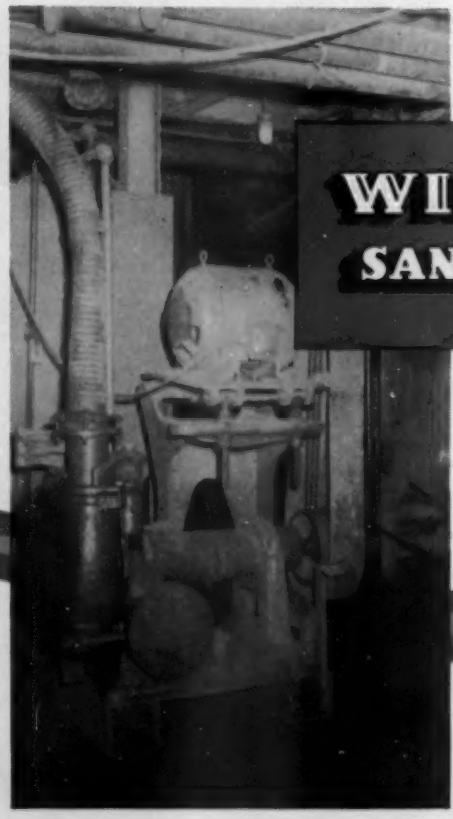
Pioneering in TACONITE

The future of American industry is closely allied with the economic processing of low-grade iron ore reserves in Minnesota and Michigan. Because of taconite's vital importance, industry is highly interested in the progress of the TACONITE PIONEERS.

Shown here is a typical example of how one taconite pioneer uses Wilfley Sand Pumps to help solve the problems encountered in handling flotation froth . . . proof again that on even the most difficult applications Wilfley Pumps meet every requirement.

Individual engineering on every application. Write, wire or phone for complete details.

Wilfley Acid Pump
"COMPANIONS IN ECONOMICAL OPERATION"
Wilfley Sand Pump



WILFLEY SAND PUMPS

A. R. WILFLEY and SONS, INC.
DENVER, COLORADO, U.S.A.
New York Office: 1775 Broadway, New York City

Published monthly by the American Institute of Mining and Metallurgical Engineers, Inc., 29 West 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220. Subscription $8 per year for non-AIME members in the U. S., & North, South & Central America; $10 foreign; $6 for AIME members, or $4 additional in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology". Single copies $.75; single copies foreign $1.00, special issues $1.50. The AIME is not responsible for any statement made or opinion expressed in its publication. Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by The National Research Bureau. Entered as second-class matter Jan. 18, 1949, at the post office at N. Y., N. Y., under the act of March 3, 1879. Additional entry established in Manchester, N. H. Member, ABC.

MINING engineering

VOL. 7 NO. 8 AUGUST 1955

COVER

"The Hill" is more than a descriptive phrase for the location of the mine at Climax—it is the phrase by which this great mining enterprise is known. But Climax the company is more than one mine and this special number devoted to the Climax Molybdenum Co. tells that story of company expansion.

FEATURES

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Geologist, M.S., 6 years experience seismograph geophysical interpretation; 2 years petrographic experience; some experience highway engineering. M-232.

Geological Engineer, 25, married, one child. Geological engineer in geology and mining. Experienced field mapping, surveying, sampling, mine layout for underground workings. Desires a position in geology, mining or sales work. M-233.

Petrologist-Mineralogist-Economic Geologist, Ph.D., 34, at present in mining exploration. Research minded. Five years teaching and 4 years industrial experience, would like industrial or research position with progressive company or state geological survey, or academic position with research facilities. M-234.

POSITIONS OPEN

Engineers. (a) Smelter superintendent, under 45, metallurgical graduate, with at least 10 years supervisory experience in lead-zinc plant. (b) Mill superintendent, under 45, mining or metallurgical graduate, with at least 10 years supervisory experience in lead-zinc flotation plant. Salary open. Location, South America. F1745.

Equipment Supervisor, preferably with engineering training and plant engineering experience covering maintenance of mining equipment. Salary, $6000 to $6500 a year. Location, South. W1772.

General Mine Superintendent, about 45, mining graduate, with at least 10 years supervisory underground experience in metal mine. Salary, $12,000 a year. Location, South. W1771.

Mining Engineer, with considerable management and executive ability in the management and operation of a gold and platinum surface mine. Salary open. Location, Northwest. W1748.

Mining Engineer, graduate, 30 to 50, experienced in highly mechanized coal mining with good practical and theoretical knowledge of mine ventilation. Duties to include supervision of underground survey crews and map draftsmen, plans for development and exploration, and mine projection. Applicant must be in good health. Salary commensurate with experience and qualifications such as professional registration. Location, Virginia. W1739.

Instructor or Assistant Professor, for dept. of mineral industries, to teach courses in general physical geology, mining engineering, and metallurgical operations. Opportunity for research and personal improvement. Location, South. W1734.

Mining Engineer, young, with underground experience, for surveying, mapping, etc., with metal mining company. Salary open. Location, South. W1725.

Instructor or Assistant Professor, in geological engineering curriculum, to teach general geology, stratigraphy, and geomorphology. Opportunity for research. South. W1713.

Teaching Personnel. (b) Geologist, with geophysics experience, to teach general exploration geophysics (undergraduate level) with some geology courses, especially structural geology and mineralogy. Rank of instructor or assistant professor, ample opportunity for advancement. (c) Mineral Economist, 25 to 35, for state geological survey, M.S. degree, to assist in conducting long-range, continuing study of mineral potential of Rocky Mountain State. Unusual opportunity for man who combines basic knowledge of mineral deposits and production with economics. Salary open. W1661.

Supervisor Minerals Beneficiation, metallurgical engineer or mining engineer, up to 45. Must have had at least 4 years experience in mineral beneficiation work and have knowledge of metallic and nonmetallic minerals. Will develop and direct minerals beneficiation program, formulate policies regarding minerals, and encourage use of these services by operating divisions. Salary, $7500 to $12,000. Employer may negotiate fee. Considerable traveling. Location, Chicago. C3310.

Plant Engineer, 25 to 35, B.S. in civil engineering or mining, with experience in connection with quarrying, mining or processing rock products. Salary open. South. W1775(a).

TEACHING POSITION: at the level of Instructor or Assistant Professor in Geological Engineering Curriculum. Should be capable of teaching general geology, stratigraphy, and geomorphology. Opportunity for research. Location North Carolina.

Box 10-H AIME
29 West 39th St. New York

GRADUATE FELLOWSHIPS OPEN
MINERAL INDUSTRY
(GEOLOGY, MINING, METALLURGY)

The Li Foundation, Inc. has established two post-graduate fellowships of $2,000 each, for 1955-56, leading to a Master's Degree at The Mackay School of Mines. They are open to citizens of the United States, and may be renewed for a second year.

Send letter containing names and addresses of 3 references, statement of academic and professional record, and recent photograph to: Vernon E. Scheid, Dean, Mackay School of Mines, University of Nevada, Reno, Nevada.

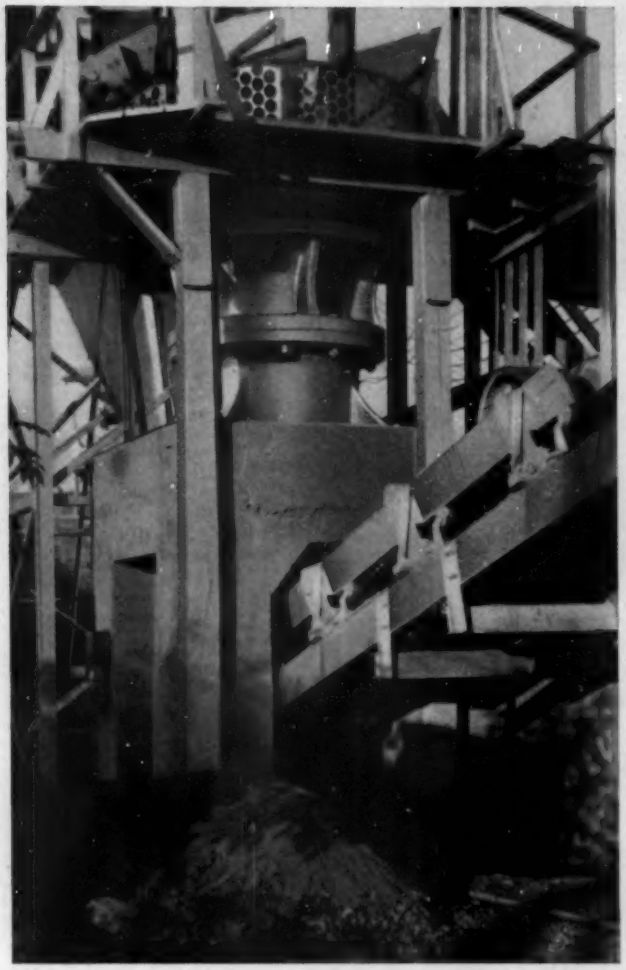
EXPLOSIVES SALES OPPORTUNITY

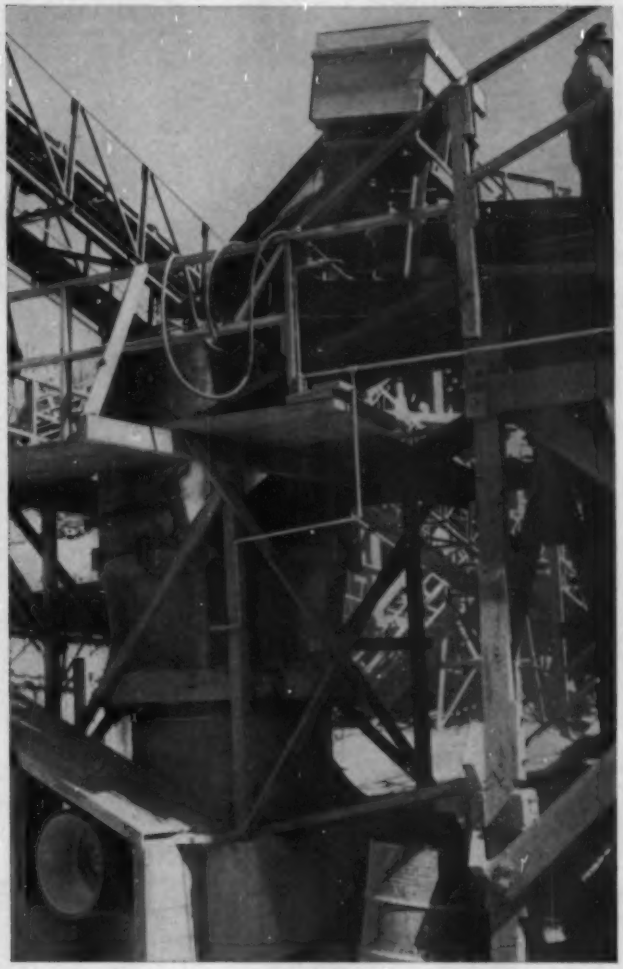
We need a man with explosives experience for an attractive sales opening. The person selected will sell and promote the sale of commercial grade ammonium nitrate for the preparation of Akremite. This permanent position in a new field is with a rapidly expanding company and offers considerable opportunity to advance.

In reply state experience, education, age, salary requirements, and any other pertinent information.

Replies should be directed to:

S. N. Gay
Sales Manager,
Commercial Products
SPENCER CHEMICAL COMPANY
Dwight Building
Kansas City 5, Missouri





Here's why 836 Operators said:
"Buy a Traylor TY Reduction Crusher"

There must be a mighty good reason why so many operators the world over would decide to buy the same machine . . . a Traylor TY Reduction Crusher.

There is. It's a matter of costs. Not first costs that occur once . . . but operating costs that go on year after year.

Low-cost operation is the big reason 836 operators decided on a Traylor TY.

A Traylor TY is a heavy duty machine built with an eye to the future. It boasts of many, many features such as bronze lined eccentric . . . spring mounted suspension . . . short head. The result is less down-time, increased production and reduced power requirements with a Traylor TY.

The full story behind the decision of hundreds of profit-wise ore producers to buy a Traylor TY is told in Traylor Bulletin 7112. Write for your copy today.

TRAYLOR ENGINEERING & MFG. CO.

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SALES OFFICES: New York • Chicago • San Francisco

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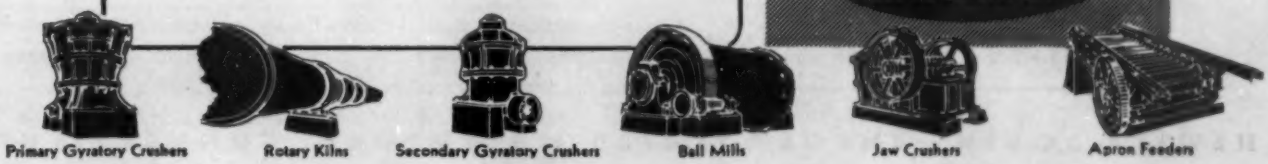
A Traylor leads to greater profits



Primary Gyratory Crushers | Rotary Kilns | Secondary Gyratory Crushers | Ball Mills | Jaw Crushers | Apron Feeders

NEW SUPER RAYNILE CONVEYOR BELT 400% STRONGER

Provides the economical answer to transporting ore and other bulk materials over long distances and up steep slopes.

This remarkable new Hewitt-Robins conveyor belt reinforced with the revolutionary synthetic fabric, Super Raynile, makes possible an entirely new concept in single-section conveyor application. It solves difficult materials handling problems where topography and other conditions require the use of a long single-length conveyor.

Already in service, Super Raynile has the highest operating tension of any conventional carcass belt. Because of its tremendous tensile strength, 400% greater than conventional cotton reinforced belts, a single conveyor section *5¾ miles long* can be built over level terrain to carry material at 400 TPH using only a 6-ply Super Raynile belt 30 inches wide. This same belt can also lift material from ground level to a height of 830 feet.

The new Hewitt-Robins Super Raynile conveyor belt is highly flexible and pliable despite its great strength. Its cost is less than steel-reinforced belts and Super Raynile can easily be spliced in the field more quickly, more economically and without the specialized equipment required to splice steel-reinforced belts.

Super Raynile belt is available in a wide range of specifications . . . widths up to 72" — thickness up to 15 plies.

Learn more about this new long-length, long-life conveyor belt. Contact your local Hewitt-Robins Industrial Supply Distributor (see Classified Phone Book), or write direct to "Super Raynile Belt", Hewitt-Robins Incorporated, Stamford, Connecticut.

Hewitt-Robins

Conveyor Belting—Industrial Hose—Conveyor Machinery—Vibrating Screens—Vibrating Conveyors—Design, Manufacture, Engineering and Erection of Complete Bulk Materials Handling Systems.

HEWITT-ROBINS INCORPORATED • STAMFORD, CONNECTICUT

GM DIESEL
CASE HISTORY No. IA3-15

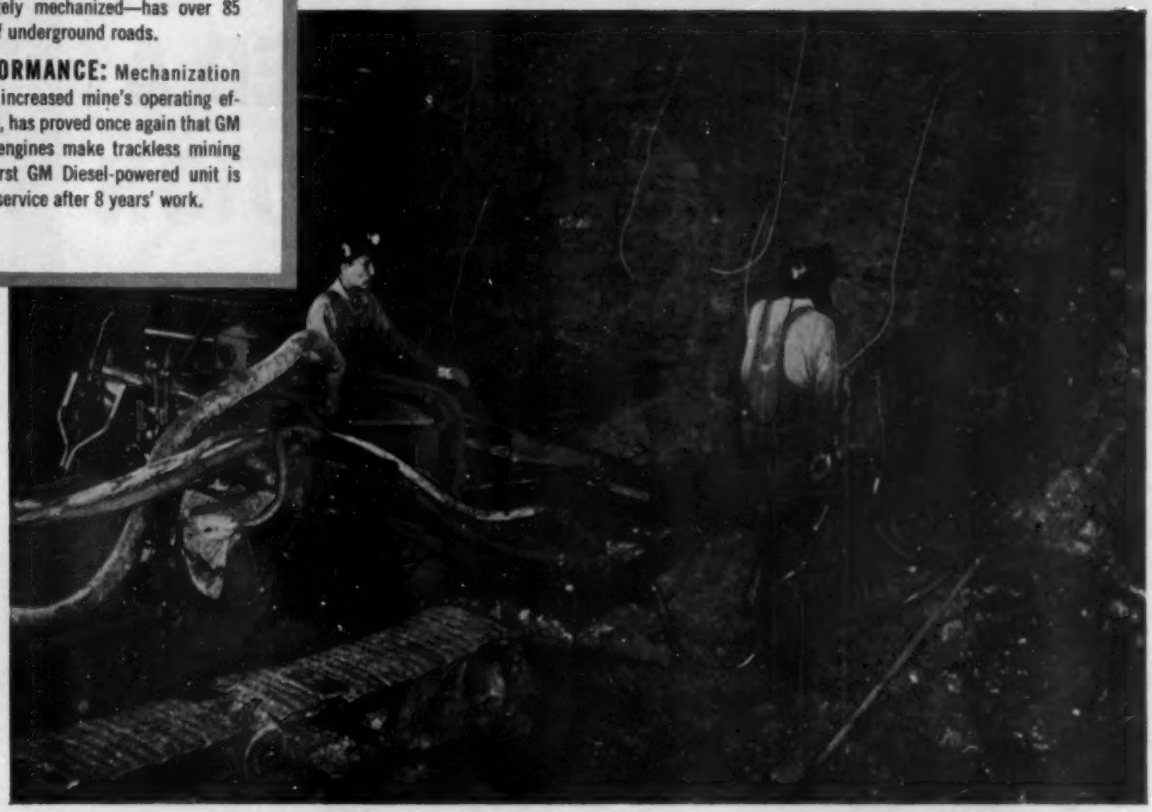
OWNER: Eagle-Picher Company, Miami, Oklahoma.

INSTALLATION: 50 GM Diesel-powered ore haulers, shovels, drills and personnel cars in zinc mine. Mine is completely mechanized—has over 85 miles of underground roads.

PERFORMANCE: Mechanization greatly increased mine's operating efficiency, has proved once again that GM Diesel engines make trackless mining pay. First GM Diesel-powered unit is still in service after 8 years' work.

8 years underground

and still going strong



To a General Motors 2-cycle Diesel engine "home" is where the job is. That's why you'll find both underground and surface (strip) miners specifying GM Diesel power for their mines.

In the Eagle-Picher underground mine, GM Diesel engines equipped with exhaust scrubbers keep production on the move.

And in both deep mines and strip mines GM Diesels help move more tons at less cost. Their 2-cycle operation with power at every piston downstroke means faster acceleration, less time spent per haul trip or bucket swing. What's more, you can run a GM Diesel for a lifetime because all parts and components are easily replaced.

Eagle-Picher executives say the local GM Diesel distributor was "invaluable" in working out some of their power problems. Back of the low-cost performance of GM Diesels *everywhere* stands a network of distributors ready to give you service and fast delivery of low-cost parts. These GM Diesel distributors are power experts. Call the one nearest you today for details on GM Diesel power for your mine.

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN
Single Engines . . . 30 to 300 H. P. Multiple Units . . . Up to 893 H. P.

VISIT GENERAL MOTORS POWERAMA Gala Celebration of 100 Million GM Diesel Horsepower—Lake Shore South, Chicago—Aug. 31st through Sept. 25th

STARTED A NOISY REVOLUTION

This was no quiet affair for it concerned—and radically altered—existing drilling practice. It started with the introduction of a new drill and a special drill steel developed to work together. This revolutionary drilling unit is the Atlas Copco light rock drill and the Sandvik Coromant tungsten-carbide-tipped drill steel. The measure of this drilling unit's success has been its rapid, wide-scale adoption throughout the drilling world—accompanied, wherever it is in use, by a change to *faster, smoother, far more economical methods.*

MORE DRILLS AT WORK. A striking advantage of this unit is the compactness and lightness of the Atlas Copco rock drill. This has practically swept away the two-man, bar-rigged drifter and with it, faces cluttered with unproductive crews and bulky equipment. *Atlas Copco rock drills are one-man machines.* That means *more* machines engaged on *actual* drilling operations at one and the same time.

CANADA *Atlas Copco rock drills fitted with Sandvik Coromant drill steels at work on the famous Alcan project, Brit. Columbia.*

DEVELOPED TOGETHER. The Atlas Copco light rock drill is only half the story of this drilling unit. From the earliest research and experimental stages, its development has been tied with that of the Sandvik Coromant tungsten-carbide-tipped drill steel. Work on both has always been towards a combination rock drill and drill steel (a drill and steel produced separately could never be as well balanced or give equivalently high performances), and has been the basis of this drilling unit's outstanding triumph.

MILES OF DRILLING TESTS. A highly important contribution to the development of this revolutionary drilling unit are the hundreds of miles of test drilling carried out each year by Sandvik at their own mine, in close co-operation with Atlas Copco. Other tests are carried out in the mine's rock-drilling laboratory and by Sandvik research teams in Sweden, South Africa and Canada. All this 'backroom' work serves to provide valuable practical information naturally influencing the enormously skilled drill steel production stages. In this, Sandvik are the world's only manufacturers of drill steels to control every phase—from the mining of the iron ore and the processing of wolfram ore to the final, *extra-hard* tungsten-carbide-tipped drill steels.

DRILLED 800 MILLION FEET. Atlas Copco drills and Coromant steels are today's most widely used pusher leg drills and integral steels. This combination is at work down mines and on construction projects throughout the world bringing *trouble-free progress, faster times, new economies and beating schedules and records.* Could there be anything more conclusive of how complete a revolution this drilling unit started than to state that in 1954 it was responsible for drilling no less than 800 million feet—or nineteen times through the globe!

BRAZIL *This circular discharge tunnel for the Paulo Afonso project was drilled by Atlas Copco rock drills fitted with Sandvik Coromant drill steels*

SWEDEN *An Atlas Copco rock drill — a one-man machine — in operation down the Persberg Mine. It is fitted with a Sandvik Coromant drill steel.*

Atlas Copco Compressed Air Equipment is manufactured or sold and serviced in 48 countries throughout the world by the *Atlas Copco Group*, which embraces companies trading under various names such as Atlas, Atlas Diesel, Atlas Polar, Atlas Copco, Copco, Delfos and Sampa.

MAIL THIS COUPON to the most convenient of the addresses given here:
U.S.A., Copco Pacific, Ltd., 930 Brittan Avenue, San Carlos, California; Copco Eastern, Ltd., P.O. Box 2568, Paterson 2, N.J.; CANADA, **Canadian Copco, Ltd., Montreal, A.M.F., Quebec;** MEXICO, Atlas Copco Mexicana, S.A., Apartado Postal 56, Torreon, Coahuila; PERU, Compania Atlas del Perú, S.A., Apartado 2982, Lima.
UNITED KINGDOM, The Atlas Diesel Co., Ltd., Wembley, Middx.; FRANCE, Atlas Polar S.A., 29, Rue Marbeuf, Paris 8e; HOLLAND, N.V. Holland-Atlas, P.O. Box 6056, Rotterdam; ITALY, S.A.M.P.A., Viale Marche 15, Milan.
AUSTRALIA, Australian Atlas Company Pty., Limited, P.O. Box 54, Auburn, N.S.W.; SOUTH AFRICA, Delfos Pty. Ltd., P.O. Box 504, Benoni, Transvaal.

Readers in countries outside those listed above and who do not know the name of their local Atlas Copco company or agent, please write, in the first instance, to AB Atlas Diesel, Stockholm 1, Sweden.

Please forward details of ***Atlas Copco Rock Drills and Sandvik Coromant Drill Steels.***

NAME .....

COMPANY .....

ADDRESS .....

.....

* I am also interested in other Atlas Copco equipment (*please state which below*)

.....

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* *Manufacturers of Stationary and Portable Compressors, Rock-Drilling Equipment, Loaders, Pneumatic Tools and Paint-Spraying Equipment*

THE ATLAS COPCO GROUP OF COMPANIES

BOOKS

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten pct discount given whenever possible.

Asbest, by Karl Frank, *Becker & Haag,* Hamburg, available in the U. S. from Stechert-Hafner Inc., approximately $3.00, 234 pp., 2d edition, 1952.—A comprehensive treatment of the technological and economic aspects of the asbestos industry: properties of asbestos, world deposits and their exploitation, mining and milling methods, markets, and applications. Detailed subject and geographical indices and a bibliography are included. In German.

America's Needs and Resources: A New Survey, by J. Frederic Dewhurst and Associates, *Twentieth Century Fund,* $10.00, 1148 pp., 1955.—This encyclopedic survey of the past achievements, present status, and future possibilities of the American economy is some 50 pct longer than its predecessor of the same title published in 1947. Its 26 chapters give statistical and analytical information on consumption of goods and services, capital requirements, Government expenditures, foreign trade, the labor force, natural resources, and productive capacity. Special attention is given throughout to the impact of new products and techniques, and two chapters are devoted to technological change and its effect on productivity.

Highway to the North, by Frank Illingworth, *Philosophical Library,* $7.50, 293 pp., 1955.—A British author's journeys along the Alaska Highway from Mile Post Zero to Fairbanks and on to Kotzebue, an Eskimo village within the Arctic Circle. He is a good listener and a portion of his book is devoted to old-timers' reminiscences of the Klondike gold rush. Illustrated with a map and 32 photographs.

Engineering Properties of Soils, by R. H. Karol, *Prentice-Hall Inc.,* $3.50, 82 pp. plus data sheets, 1955.—Techniques and procedures of performing laboratory tests on soils. The author is with Esso Research & Engineering Co. and adjunct professor, civil engineering, Graduate Div., Newark College of Engineering. Sample computations, examples of test results, and equipment photographs are included where helpful. Theory is presented only when pertinent. For the student a working knowledge of basic engineering courses is presupposed.

Geology, Principles and Processes, by William H. Emmons, George A. Thiel, Clinton R. Stauffer, and Ira S. Allison, *McGraw-Hill Book Co. Inc.,* $6.50, 638 pp., 4th edition, 1955.—Topics of the previous edition are reorganized, revised, and augmented by new material that includes: a more complete presentation of chemical weathering, a discussion and classification of soils, new concepts regarding the mobility of rocks in relation to mountain building, and additional data on the origin and geological setting of nonmetallic mineral resources.

Please Order Publications Listed Below from the Publishers

Geochemical Prospecting in the Zinc-Lead District of Northwestern Illinois, by J. C. Bradbury, *State Geological Survey Div.,* Urbana, Ill., 25¢, 11 pp., 1955.—According to the author, the rapid dithizone method "does not appear to be effective in locating orebodies in the district, but may indicate areas of mineralization by high readings of valley silts."

Classification of Rocks, by Russell B. Travis, *Quarterly of the Colorado School of Mines,* Golden, Colo., Volume 50, No. 1., $1.00, 98 pp., 4 fig., 66 pl., 3 charts, January 1955.

Stresses around Mine Openings in Some Simple Geologic Structures, by R. D. Caudle and G. B. Clark, Engineering Experiment Station Bulletin No. 430, *University of Illinois,* Urbana, Ill., 65¢, 42 pp., 1955.—An analysis of underground stresses that may be applied to certain geologic structures to clarify some points of fundamental research previously neglected. Bibliography, 28 figures.

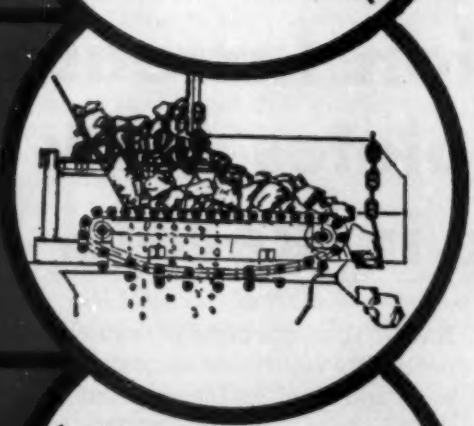
(Continued on page 698)

ROSS Material Handling Equipment

Operation Diagram of :—

ROSS CHAIN FEEDER

Completely controls the flow of any size material from storage bins and open dump chutes to crushers, conveyors, screens, etc.



Operation Diagram of :—

ROSS DROP-BAR GRIZZLY FEEDER

Every other bar drops away automatically at the discharge end, ensuring free passage for fines and presenting clear unblocked apertures to the feed.

Operation Diagram of :

ROSS TWO-ROLL GRIZZLY Separates material with extraordinary rapidity and completeness. Rear-roll surfaces are smooth. Front roll has shallow "lifting" teeth that keep the apertures permanently clear.

N.B. ROSS CHAIN FEEDERS HAVE BEEN FEEDING THE PRIMARY JAW CRUSHERS AT CLIMAX FOR OVER TWENTY YEARS.

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100 QUIMBY STREET
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ROSS ENGINEERS LTD.
11 WALPOLE ROAD
SURBITON, SURREY, ENGLAND

Canadian Licensee: E. Long Ltd., Orillia, Ontario

Uranium Production Increased... Kerr-McGee Completes New Plant at Shiprock in Record Time

The Navajo Uranium Division of Kerr-McGee Oil Industries Inc., Shiprock, New Mexico, began operation November 1, 1954, at a tonnage greatly exceeding its planned capacity.

WKE Division of Western Machinery Company was given the go ahead on initial construction of buildings and facilities just nine months before final completion.

NEW Flowsheet. The carefully developed flowsheet, incorporating the new acid cure method of uranium concentration, was given constant and continuing study by Kerr-McGee metallurgists, the AEC, Navajo Uranium plant personnel and by WKE engineers. The result was optimum utilization of equipment and facilities for maximum recovery from the wide variety of ores submitted for treatment.

Progressive Engineering Pays Off. The new process necessitated progressive engineering and many problems impossible to foresee were worked out during design and construction, thus producing a better mill in record time.

The new $3,000,000 Kerr-McGee plant constructed by Western Knapp Engineering incorporates the latest methods for extraction of uranium concentrates. Every modern metallurgical facility has been engineered into this model custom mill.

"For complete information write for Bulletin G1-B4, Dept. C"

W.K.E.

WESTERN KNAPP ENGINEERING CO.

DIVISION OF WESTERN MACHINERY COMPANY

760 Folsom Street • San Francisco 7 • California

Record Tonnage Produced at Navajo Uranium Division

WEMCO Equipment Resists Highly Abrasive and Corrosive Treatment

New $3,000,000 Uranium producing mill of Kerr-McGee at Shiprock, N.M. built by WKE Division of Western Machinery Company.

Wemco Diaphragm Pumps handling thickener underflow are simple to adjust and service.

The new $3,000,000 plant built for Navajo Uranium Division of Kerr-McGee Oil Industries selected equipment on the basis of resistance to highly abrasive and corrosive conditions.

This new uranium plant at Shiprock, New Mexico, utilizes an acid cure flowsheet new to uranium processing. While much of the process is highly secret, it is well known that the corrosive acid content is high and damaging to equipment. Also, the fast settling coarse sands create an abrasive action which constantly exposes new surfaces to the adverse effects of corrosion.

Wemco Equipment in Flowsheet

Following grinding and screening, the liberated uranium ore is processed for repulping through WEMCO rubber covered agitators producing a pulp approximately 50% solids.

From the WEMCO Agitators the pulp flows through four WEMCO Spiral Classifiers in the modified CCD system for sand-slime separation. Exposed rotating parts of the classifiers are stainless steel with the spiral flights and tanks rubber covered to resist acid and abrasion. Acid proofing of the classifiers, including the submerged bearings and spirals, has been 100% effective. Flights can be added changing the classifiers from single to double or triple pitch if additional capacity is desired.

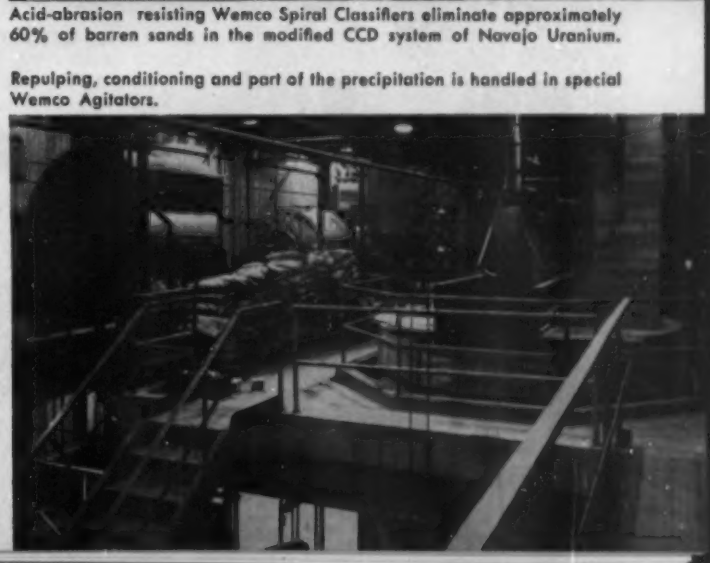
Underflow from the thickeners is handled in special acid resistant WEMCO Diaphragm Pumps. These pumps are designed for ease of maintenance and handling, with replacement of wearing parts reduced both in time and in frequency.

Precipitation of the final product utilizes specially developed WEMCO Agitators in part of the flocculating process.

"For complete information write for Bulletin G1-B4, Dept. C"

Acid-abrasion resisting Wemco Spiral Classifiers eliminate approximately 60% of barren sands in the modified CCD system of Navajo Uranium.

Repulping, conditioning and part of the precipitation is handled in special Wemco Agitators.



WEMCO®
WESTERN MACHINERY COMPANY

760 Folsom Street • San Francisco 7 • California

Representatives in principal U.S. cities, in Canada and worldwide

Check Up On Grinding Ball Performance . . . Do You Have The Best Ball In Play?

Ask the "Ump" why he doesn't allow a scuffed, out-of-round baseball or one with soft spots to stay in play. He'll tell you it handicaps the batter and is a detriment to the game.

In leading mills around the world there are plenty of buyers who will tell you that Sheffield Moly-Cop Balls grind out the lowest cost-per-ton-unit ground. Why? Because of the exceptionally fine balance of toughness and deep hardness, Moly-Cop Grinding Balls keep their shape longer—grind out savings by reason of longer, uniform wear.

A Sheffield man stands ready to demonstrate this in your mills under your own particular grinding conditions.

SHEFFIELD

ARMCO

MOLY-COP

COPPER-MOLYBDENUM-ALLOY

Grinding Balls

product of over 25 years of "Know How."

SHEFFIELD STEEL

DIVISION

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News
Equipment
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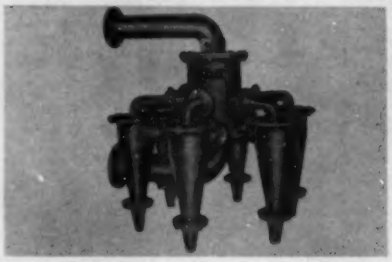
Liquid Cyclones

Cyclones now being offered by *Centrifugal & Mechanical Industries Inc.* feature maximum number of units in minimum space. Manifold-mounted Clust-R-Clones have one to



four 10-in. cyclones, one to six 8-in. cyclones, or one to twelve 4-in. cyclones. There is also a model with single 20-in. cyclone. **Circle No. 1**

Bigger Crawler

A boost to 103-drawbar hp at 1450 rpm is feature of *International Harvester's* TD-18A which now has 24,300 lb drawbar pull. Six forward

and two reverse speeds are standard as is a 17 pct larger air cleaner. Fuel tank capacity has been upped to 75 gal. New engineering techniques have given greater durability to the new model which has 300 pct stronger track frames. Machined surfaces are designed to assure fit and posi-

tive track alignment. Operator comfort has been emphasized through fully adjustable padded operator's seat and compactly arranged control levers. Safety has been stressed in a new system of positive self-energizing brakes. **Circle No. 2**

Quick Clamp

A general purpose hose clamp has been developed by *Circle Clamp Corp.* that can be installed in 3 sec with ordinary pliers. Simplified application of clamps available in sizes from ¼ to 2 5/8 in. is said to save time and reduce costs. **Circle No. 3**

High Speed Core Drill

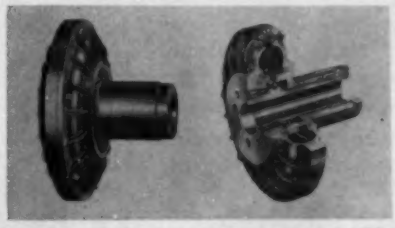
Sprague & Henwood announced development of two new diamond core drilling machines, the 30 and the L-2. Both aim to meet need for compact, easily moved units, capable of rapid coring to moderate depths and offer options of diesel, gasoline, air, or electric drive. Skid mount, trailer mount, or complete self-contained rig on four-wheel drive truck are offered. Model 30 is rated to 600 ft with EX or 300 ft with NX, and model L-2 is rated 500 ft with EX or 400 ft with AX core. **Circle No. 4**

Lead for Lubrication

Lead-Cote open gear and wire rope grease manufactured by *Howard Drullard Co.* contains 25 pct of —350 mesh metallic lead. Claimed nearest approach to permanent gear lubricant. Users report 80 pct reduction in grease consumption. Already widely used, the grease is suitable for both open gears and for cable protection, offering low friction, noise reduction, economy, cleanliness, and long protection. **Circle No. 5**

Dry Fluid Drive

Flexidyne dry fluid drive introduced by *Dodge Mfg. Corp.* provides new way to start loads smoothly, protect against shock and overload,



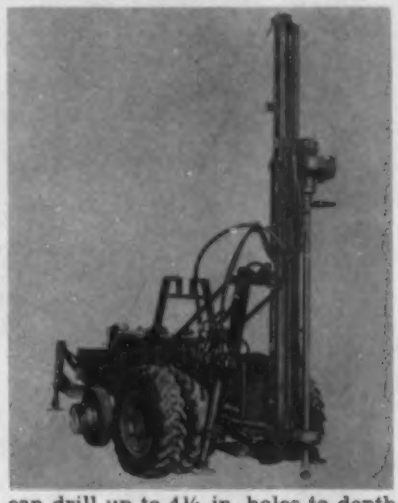
save power and still have no-slip drive at full load. Proved by thousands of installations in Europe, drive utilizes fluid of fine steel particles in a housing. Design may be readily applied to existing motor installations, and Flexidyne offers a range of slip from 20 pct to full motor torque, to suit installation. **Circle No. 6**

Flowmeters

Mercury-less transmitters in several choices are offered by *Hays Corp.* Units are suitable for differential pressure, liquid level, flow, temperature, or pressure measurement applications. **Circle No. 7**

Mobile Rotary

Schramm Inc. has brought out a self-contained unit for rotary drilling with compressed air. The Rotadrill mounted on a pneumatractor



can drill up to 4¼-in. holes to depth of 500 ft and requires only one operator. Design provides 10,000 lb down pressure. Mast lowers for travel and tilts for sloping holes. **Circle No. 8**

Better Belts

An electronic method of making rubber V-belts produces belts almost free from vibration and of greater uniformity. *U. S. Rubber Co.* disclosed manufacturing technique that will result in longer belt life, less vibration, and lower pulley wear. **Circle No. 9**

Screen Improvement

Wedge Wire Corp. is marketing a Marcel-type Kleenslot screen, specifically designed for operation where slivers passing through are objectionable in the product. Special construction breaks up slivers in most cases. **Circle No. 10**

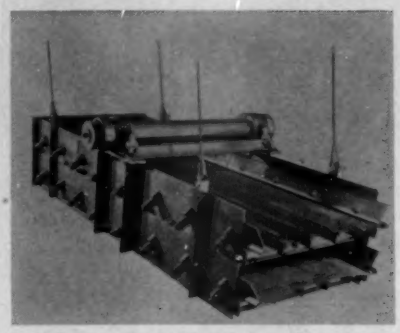
Optical Transits

The optical midget transits built by Aksania Werke AG, Berlin, are being distributed in the U. S. by *Geo-Optic Co.* Accuracy to 1 min, estimation to 6 sec, optical plummet, are among features of the 4½-lb transit. Other products distributed by Geo-Optic are the Ott Planimeter, and a warp-free aluminum inserted drawing paper. **Circle No. 11**

Simpler Screening

Model AVS Aero-Vibe screen with simplified two-bearing design, counterweight wheels, and bolted construction was announced by *Allis-Chalmers.* Built to handle feeds up

Mfrs. News . . . .



to 4-in., and coal to 6-in., the screen can make separations from 1½ in. to 35 mesh. Models are available with one, two, or three decks in sizes from 3x6 to 4x10 ft. **Circle No. 12**

Rubber Chute Lining

A metal-backed rubber chute lining for basic construction or installation on existing structures has been marketed by the Industrial Products Div. of *Goodyear Tire & Rubber Co.* Called Armaplate, it consists of abrasive resistant rubber bonded to hot-rolled steel sheet. It can be formed, sawed, sheared, rolled, bent, and punched like steel sheet. The lining can be bolted or tack-welded for chute application. **Circle No. 13**

Shuttle Car

General Electric has introduced a permissible shuttle car for coal mine use from face to haulage system. Simple control, increased maneuverability, extra traction power are features of the 8-ton capacity car. Height is 43 in., without sideboards. Operation is on 250 or 500 v. **Circle No. 14**

Scintillation Counter

Jeb Instruments is offering the Special Groundaire counter at $249.50. Instrument has four sensitivity ranges, two time constants, and other advanced features. **Circle No. 15**

Model Changes

Designated the series C, the new *Caterpillar* DW15 features 186-hp engine, new transmission case, and the proved No. 27 cable scraper con-

trol. Caterpillar also announced two additions to its rubber-tired tractor line, the DW21 series C and DW20 series E. Both use a 300-hp, 805-cu in. engine with turbocharger. **Circle No. 16**

(Continued on page 692)

IMPOSSIBLE WITHOUT EXPLOSIVES

On a mountainside in West Virginia, overburden up to 80 feet in height—sandstone, shale, and slate—is blasted with the correct type of Hercules® dynamite to uncover seams of coal 7 ft. thick. Speedy, economical shovel-loading operations are maintained by loosening the coal with small charges of explosives.

Hercules has long pioneered in developing explosives for every type of project. Our experience and service facilities can help you solve blasting problems in mining, quarrying, construction, seismic explorations—wherever explosives are needed to get a job done.

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HERCULES

XR66-4

Mfrs. News . . . .

Grizzly-Feeder

Simplicity Materials Handling Ltd. is producing an oscillating feeder with a grizzly deck. Dual operations of apron feeder and stationary grizzly are combined to cut costs and

save half the space formerly needed. Simplicity Grizzly-Feeder is available in sizes from 2x8 to 6x12 ft with capacities to 1000 tph. Unique double shaft assembly allows unit to feed on horizontal when headroom is limited. Wearing surfaces can be equipped with replaceable liners. **Circle No. 17**

New Grader

Allis-Chalmers presents the model D diesel motor grader with an A-C 6-cyl, valve-in-head diesel engine rated 50 brake hp at 1625 rpm. The model D motor grader will still be available with gasoline engine. The new diesel engine has a 3 7/16-in. bore and 4⅛-in. stroke, and 230-cu in. piston displacement. **Circle No. 18**

Sensitive Meter

Menlo Research Laboratory offers a lightweight survey meter for beta and gamma radiation, called Menlolab Mark VII. It features 0.01 mr/hr sensitivity and has a three-range stopping switch, x1, x10, and x100. Response to radioactivity is reflected by a flashing NE5 neon bulb. **Circle No. 19**

Concrete Gun

A concrete gunning machine has been added to the line of the *Air Placement Equipment Co.* The Airplaco Nucretor is designed for operation where larger quantities of concrete are to be placed. It has a maximum capacity of 6 cu yd of aggregate per hr with a complete range of capacities from ½ to 6 cu yd per hr. **Circle No. 20**

News and Notes

Standard Ore & Alloys Corp. has been appointed U. S. licensee for the uranium leaching and precipitation process controlled by Canadian Patents & Development Ltd. These include process now used at the Beaverlodge property controlled by the Canadian Government . . . *Sutton Engineering Co.* has transferred executive and sales offices from Bellefonte, Pa., to the First National Bank Bldg., Pittsburgh 22 . . . *Texas Instruments Inc.* has appointed Computing Devices of Canada Ltd. its exclusive Canadian agent.

(21) DRY TRANSFORMERS: *Allis-Chalmers'* totally enclosed dry-type transformers with NEMA group 3 class insulation for indoor or outdoor applications are shown in bulletin 61B8222. Units are designed for higher temperatures to keep weights and dimensions as low as possible.

(22) AGGLOMERATION: American Ore Reclamation Section, Engineering & Construction Div., *Koppers Co.*, has a 24-page booklet discussing pertinent facts on ore agglomeration: sintering, pelletizing, nodulizing, briquetting, extrusion, and numerous variations of these processes for particular requirements. Brochure has double-page charts giving flow diagram of a sintering plant.

(23) PORTABLE CORDS: Bulletin from *Anaconda Wire & Cable Co.* shows a complete line of portable cords for rugged applications. These include industrial cord, service cord, and a new Securityflex cord, said to last longer under abuse than any other cord.

(24) SLUSHER CATALOGUE: *Vulcan Iron Works Co.* has a slusher catalogue DB-5506 on a complete electric slusher line covering range 10 to 150 hp. Two and three drum single-shaft machines as well as the new tandem style are offered.

(25) NONELECTRIC MAGNETS: Newest magnetic units in *Eriez Mfg. Co.* brochure B-207 are: Ferrotraps for removing unwanted iron from pipelines; dip tank magnets for removing iron and steel parts from tanks, bins, etc.; and the Sand Slinger magnet for removing tramp iron from molding sand traveling 375 fpm in quantities of 700 to 2000 lb per min.

(26) IQ TESTS: *Science Research Associates* has an industrial catalog on tests and other materials for use in personnel selection and training. Included are intelligence, interest, and personality tests, as well as tests for measuring aptitudes and skills.

(27) CENTRIFUGAL AIR WASHERS: Bulletin W-555 explains *Ducon Co.* principle of centrifugal air washers for wet dust collection. They have proved effective in foundry and other mechanical operations as well as for cleaning exhausts from rotary dryers, roasters, and pulverizers.

(28) DRUM SEPARATOR: Bulletin 87 from *Stearns Magnetic Inc.* features WPD model M permanent magnetic drum separator, designed to provide "efficient magnetic recovery of magnetic media as used in heavy density separation plants." Unit incorporates a fixed magnet assembly mounted inside an outer rotating cylinder. The cylinder acts as a carrier for magnetic solids attracted to the magnet assembly.

(29) EARTHMOVER—1955: *Chiksan Co.* has an illustrated brochure on the Intelli-Giant, a hydraulic gun that operates at 30 to 300 lb water pressure. Operator in sitting position controls movement of gun—320° horizontally, 120° vertically—with no effort.

(30) REVOLVING CRANE: Individually powered electric wheels make *R. G. LeTourneau's* self-propelled diesel-electric revolving crane particularly useful in off-road operation. For spot-to-spot loading jobs, unit has electrically powered outriggers set and retracted from within operator's cab.

Free Literature

(31) TROLLEY LOCOMOTIVES: Illustrating the types most widely in demand by coal mines, each of the locomotives in *Goodman Mfg. Co.'s* catalog G-102 was built to suit the exact requirement of a specific order.

(32) HARD SURFACING, WELDING: Two ideas are available from *Rankin Mfg. Co.* Form A-7 is a new idea in cutaway templates for measuring the wear of Caterpillar rails, sprockets, idlers, grousers, and rollers. Form A6-1 is a reference chart giving specifications for Caterpillar, International, and Allis-Chalmers tractor, rollers and idlers. This sheet shows how to apply Ranite to tractor and shovel parts to insure longer life.

(33) CRANE CAPACITY PLUS: *Sauerman Bros.'* field report 228 tells how to extend the reach of your crane and in many cases double its capacity with a Crescent scraper. Method is illustrated by a layout drawing and on-the-job photos.

(34) FLOCCULATION: Filtration or thickening problems? The mineral dressing dept., *American Cyanamid Co.*, has a five-page brochure on Aerofloc reagents.

(35) GEAR DRIVES: A complete line of parallel shaft gear drives is shown in the 32-page book 2619 from *Link-Belt Co.* Listed are 39 standard size drives for vibration-free transfer of power, together with baseplates and built-in backstops.

(36) CUPRONICKEL ALLOYS: Available from *International Nickel Co.* is a reprint of "Corrosion Resistance of Cupronickel Alloys Containing 10 to 30 Percent Nickel." Written by Frank LaQue, the 12-page booklet has 15 tables and 5 figures.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Nov. 15, 1955—if mailed in U. S. or Canada

Please send me { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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61	62	63	Students should write direct to manufacturer.						

Name_____ Title_____

Company_____

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City and Zone_____ State_____

(37) TRACTOR SHOVELS: Catalog 1250-P from *Clark Eqpt. Co.* covers the all-wheel drive Michigan model 175-A, with a 2¼-cu yd capacity that makes it the biggest rubber-tired tractor shovel available, and the smaller 1⅝-cu yd model 125-A.

(38) POWER UNIT: Pamphlet from *International Harvester Co.* gives full specifications and performance charts on the UD-525. This diesel power unit develops 115 hp at 1800 rpm and without radiator, fan or clutch, 121 hp at 1800 rpm. Six-cyl, 4-cycle diesel engine has 15.4 to 1 compression ratio.

(39) TESTING: *Magnaflux Corp.* publishes "Magnafacts," a magazine devoted to the application of nondestructive testing in manufacturing and maintenance, "for greater economy, better quality, increased safety." Lead article tells how Peoria Malleable Casting Co. saved money with a Magnaflux-Magnaglo unit.

(40) CEMENTED CARBIDES: Booklet available from *Kennametal Inc.* describes company facilities; products and applications; characteristics and grades; and outlines the mechanical and physical properties of Kennametal and Kentanium. The first is a series of cemented hard carbide materials; the second an engineering material for use at elevated temperatures.

(41) COMPRESSOR: Form 2302 from *Ingersoll-Rand* features the 3R, 36 cfm self-contained Spot-Air portable compressor and shows the many tools it will operate. Weighing only 265 lb, the Spot-Air can be carried by two men or pushed on a wheelbarrow mounting by one man.

(42) SCINTILLATION: *Allied Geophysics,* said to be the world's largest manufacturers of portable radiation instruments, has a new catalog on scintillation counters. A guide to instrument selection shows the models to be used for uranium; for metal location (mine detector type); for medical, laboratory, and industrial uses; and for civil defense.

(43) HIGH TENSION SEPARATION: Literature from *Carpco Engineering & Mfg. Co.* discusses high tension separation behavior of various minerals. Accompanying the general bulletin are data sheets on industrial and laboratory high tension separators and on the 40,000-v peak rating Carpco rectifier.

(44) TRACTORS: *Caterpillar Tractor Co.'s* "Low Cost Producers" shows four-wheeled tractors equipped with scrapers and wagons giv-

ing faster loading, better hauling, and controlled dumping on a variety of jobs throughout the world.

(45) STEEL GRAB: Bulletin 0902-1 from *Mine Safety Appliances Co.* explains the MSA steel grab, a heavy load grip for either vertical or horizontal pulls of steel plate or structural forms. Operating on the principle of tongs, double acting jaws automatically grip both sides of steel plate when load is applied. G-118 handles thicknesses up to 1⅛ in., weight up to 12,000 lb; G-58, thicknesses up to ⅝ in., weight up to 6000 lb.

(46) FIREBRICK: Bulletin R-34 from Refractories Div., *Babcock & Wilcox Co.,* lists properties and characteristics of B&W's Allmul, Allmul D., 80, 80-D, and Junior Firebrick. Illustrated are typical applications of these firebricks in a wide variety of industrial furnaces.

(47) WASHING PLANT: *Pioneer Engineering Works* has an 8-page bulletin on features, contruction, performance, and operation of the king-size Pioneer 405-W scrubbing, washing, and sizing plant for sand and gravel. A 2-page cutaway shows the flow through the plant, which can turn out up to five graded sizes in addition to the oversize.

(48) PUMPS: *Denver Eqpt. Co.'s* bulletin P8-B9 discusses heavy duty adjustable stroke diaphragm pumps in sizes to 6 in. quadruplex units with capacity of 92 c.m (water). Recommended service: thickener underflow, metering feed to process units, and pumps for filtrate.

(49) FLEXIBLE HOSE: *Flexaust Co.* has a set of bulletins of interest to anyone concerned with design, installation, or purchase of flexible hose used in dust and fume control, air conditioning, and materials handling. They contain general information, accessories, friction loss, and other useful data.

(50) COAL RECOVERY: *Salem Tool Co.'s* bulletin M-101 on hydraulic and manual models of McCarthy coal recovery drills contains specifications on power feed drills using 6-ft augers from 16 to 42 in. diam. Various drills are equipped with manual jib boom and hoist, manually operated auger guide and corner jacks, as well as power operated cable jacks.

(51) WET PROCESSING: Bulletin 2504 from *Dorr-Oliver* explains the M Dorrclone, a compact, cylindroconical classification unit utilizing centrifugal force in place of gravity. Unit consists of molded rubber block cyclones, either 30 or 50 mm diam, installed in a common housing. Developed for 10 to 20-μ separations, it bridges gap between standard 3-in. DorrClone and 10 and 15 mm TM.

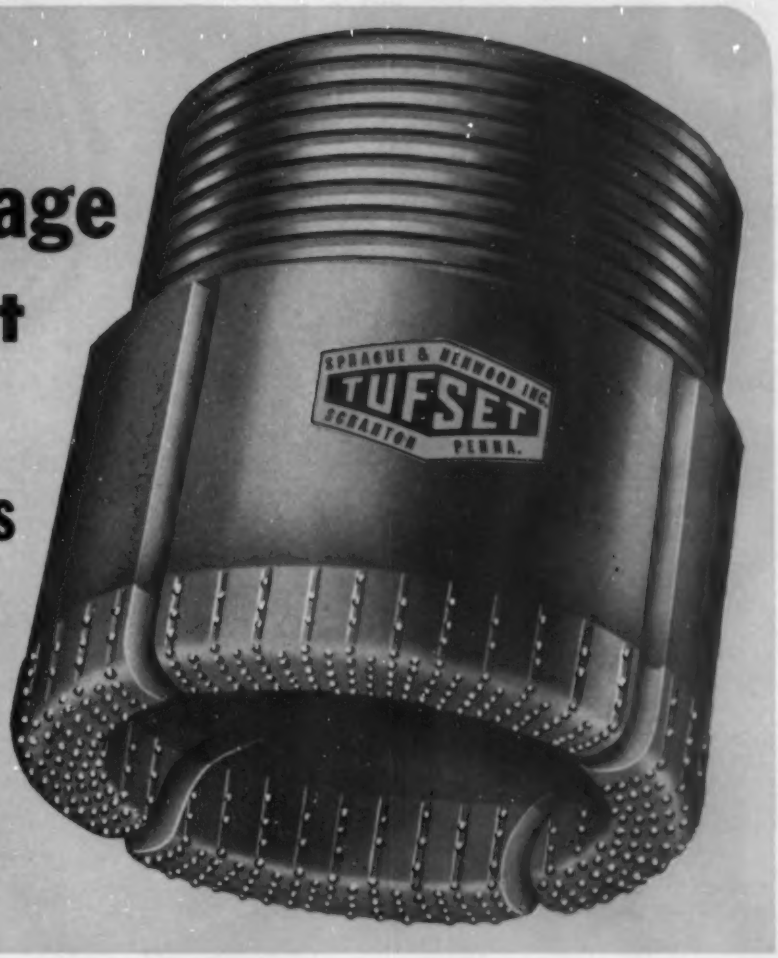
(52) SCREENING: *Southwestern Engineering Co.'s* catalog shows equipment now "successfully screening more than 241 different materials." Among industries where company has collected application data are: stone, clay, chemicals, petroleum, metals, waste and pollution control.

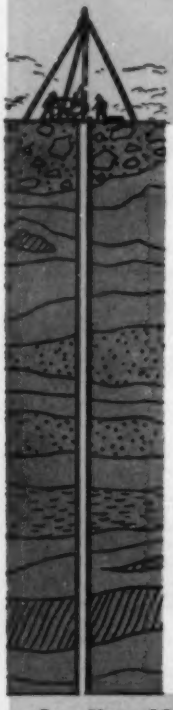
(53) SODIUM DISPERSIONS: *Ethyl Corp.* has a brochure outlining the many ways that sodium dispersions can be used to speed chemical reactions. Among present and potential uses are the treating of hydrocarbons and petroleum and the preparation of metal powders, sodium hydride, sodium cyanate, alkyl sodium amides, alcohol-free alcoholates, and phenylsodium.

(54) TUNGSTEN CARBIDE TOOLS: Included in catalog VR-485 from *Vascoloy-Ramet Corp.* are bits for chain cutters, roof drills, auger drills, and rotary drills. A chart shows practical uses and recommended drill steels for percussion bits.

(55) LABORATORY RECORDER: *Fisher Scientific Co.* has a 12-page bulletin on the Fisher Recordall that "converts manual laboratory instruments into automatic, recording instruments." This instrument records changes in potential, current, resistance, temperature, pH, pressure, vacuum, rotational speed, illumination, transmittance, reflectance.

You'll Get Greater Footage at Lower Cost with Sprague & Henwood's ORIENTED DIAMOND BITS





AFTER extensive comparative tests, conducted in cooperation with the U. S. Bureau of Mines, had PROVED that drill diamonds cut faster and last longer when "oriented" in the matrix with their hardest edge or "vector" toward the work, we decided that random setting was obsolete. Since then we have standardized on oriented diamond bits and have produced THOUSANDS—in a wide variety of types and sizes, with both cast- and powdered-metal matrices—to meet every diamond drilling requirement.

For either core drilling, or any type of non-core drilling, we believe these to be the most efficient and economical diamond bits ever produced and invite inquiries on that basis. Bulletin No. 320 illustrates all types and gives complete working data. Write for a free copy and tell us about your drilling conditions. Our experienced executives welcome opportunities to make money-saving suggestions without charge or obligation.

WORLD-WIDE CONTRACT DRILLING

For more than seventy years Sprague & Henwood, Inc. has been a leader in the field of Contract Diamond Drilling. During this long period of time our crews have completed thousands of contracts successfully, under every conceivable operating condition, in almost every part of the world. Today we have a large force of expert operators and an ample supply of modern equipment, so that we can undertake practically any job, anywhere, on short notice. Estimates submitted promptly on request.

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Leading Manufacturers, also, of High-Speed Diamond Core Drilling Machines and a complete line of Improved Accessory Equipment for Diamond Drilling and Soil Sampling. Write for illustrated catalogues containing complete specifications and all necessary working data on:

Auger Bits, all types
Bails, lifting
Ball-Bearing Waterswivels
Bits, Diamond
Bits, Blank
Bits, Chopping
Bushings, Rod & Casing
Casing, Flush Coupled
Casing Taps
Clinometers
Corebarrels, all types
Corebarrel Taps
Core Lifters
Couplings, Rod
Derrick Sheaves
Drill Rods
Drilling Machines
Drive Hammers
Drive Heads
Drive Pipe
Drive Pipe Couplings
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Reamer Shells
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Rod Taps
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Subs
Taps, Fishing
Testers, Sample
Testers, Pressure
Wash Plugs
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Tailings Handling Made Easy

Closeup of 275 ft. dia. Dorr Thickener during final stages of construction. Part of Hydroseparator is visible behind walkway.

7450 TPD of copper tailings can be a big headache without proper disposal facilities. At a new Concentrator in Arizona the proven Dorr Hydroseparator-Thickener team is taking shock loads and variable feed characteristics in stride.

The giant Thickener — 275 ft. in diameter — dominates the picture. But equally important to successful operation is the 30 ft. diameter Dorr Hydroseparator. By scalping out oversize material ahead of the Thickener, the Hydroseparator boosts thickening capacity and cuts water losses in the underflow.

We'd like to tell you more about Dorr-Oliver's ability to provide the correct solution to tailings handling problems. Just drop a note to Dorr-Oliver Incorporated, Stamford, Conn. or in Canada, 26 St. Clair Ave. East, Toronto 5.

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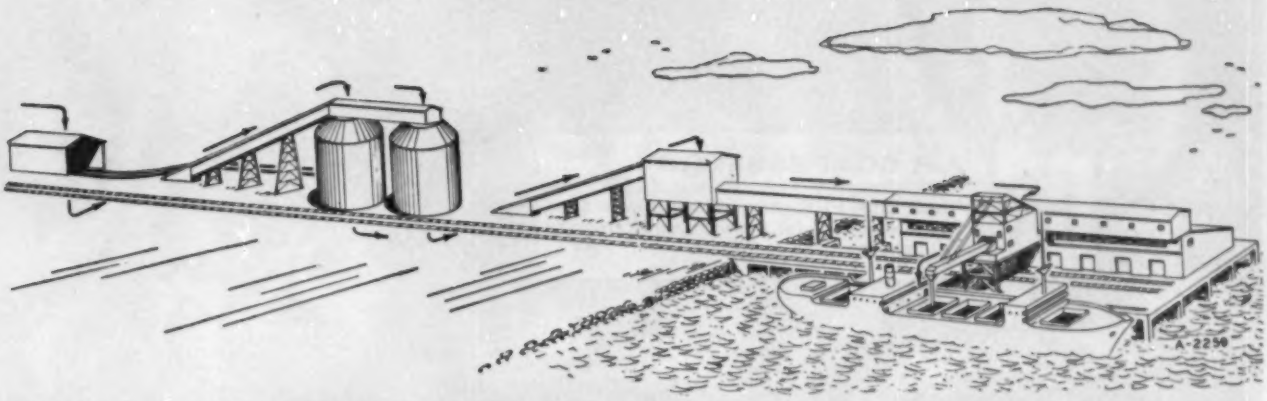


Moving JAMAICA ALUMINA TO CANADA— Economically

It's a long haul from Port Esquivel, Jamaica, to Kitimat, British Columbia. It is the combination of economic hydro-electric power developed by the Aluminum Company of Canada and reduced handling costs in the transport of pure alumina that makes this 5,000-mile production line a sound industrial enterprise.

To help do the job, special port facilities in Jamaica were designed and furnished by Stephens-Adamson. Here bulk alumina is moved, stored and loaded directly into ships' holds at a 660-tons per hour rate. The facilities and equipment are engineered to hold handling time and labor to a minimum and to make maximum use of shipping space.

To reduce shipping costs, raw bauxite is reduced to pure alumina in operations adjacent to the mine. It is brought to dockside in rail cars and discharged to a track hopper. A 30-inch belt conveyor takes it to two huge silos, each holding 10,000 tons.

When a ship arrives for loading, alumina is withdrawn from storage by a 48-inch belt conveyor. From a transfer house, another conveyor runs along a gallery parallel to the dock. A traveling tripper feeds to a traveling gantry boom discharging through a chute to an S-A ship trimmer that throws alumina to all parts of the hold for uniform loading.

This efficient loading and handling system is a good example of S-A engineering at work. For any bulk handling job, S-A is at your service to help you cut your bulk handling costs. Write for a free survey—no obligation, of course.

48-inch belt conveyor, supported by traveling gantry, feeds alumina to S-A ship trimmer at rate of 660 tons per hour. High speed belt throws alumina to farthest corners of hold.

Conveyor gallery running parallel to dock. Tripper in background feeds alumina to boom belt conveyor.

SINCE 1901 S-A STEPHENS-ADAMSON MFG. CO.

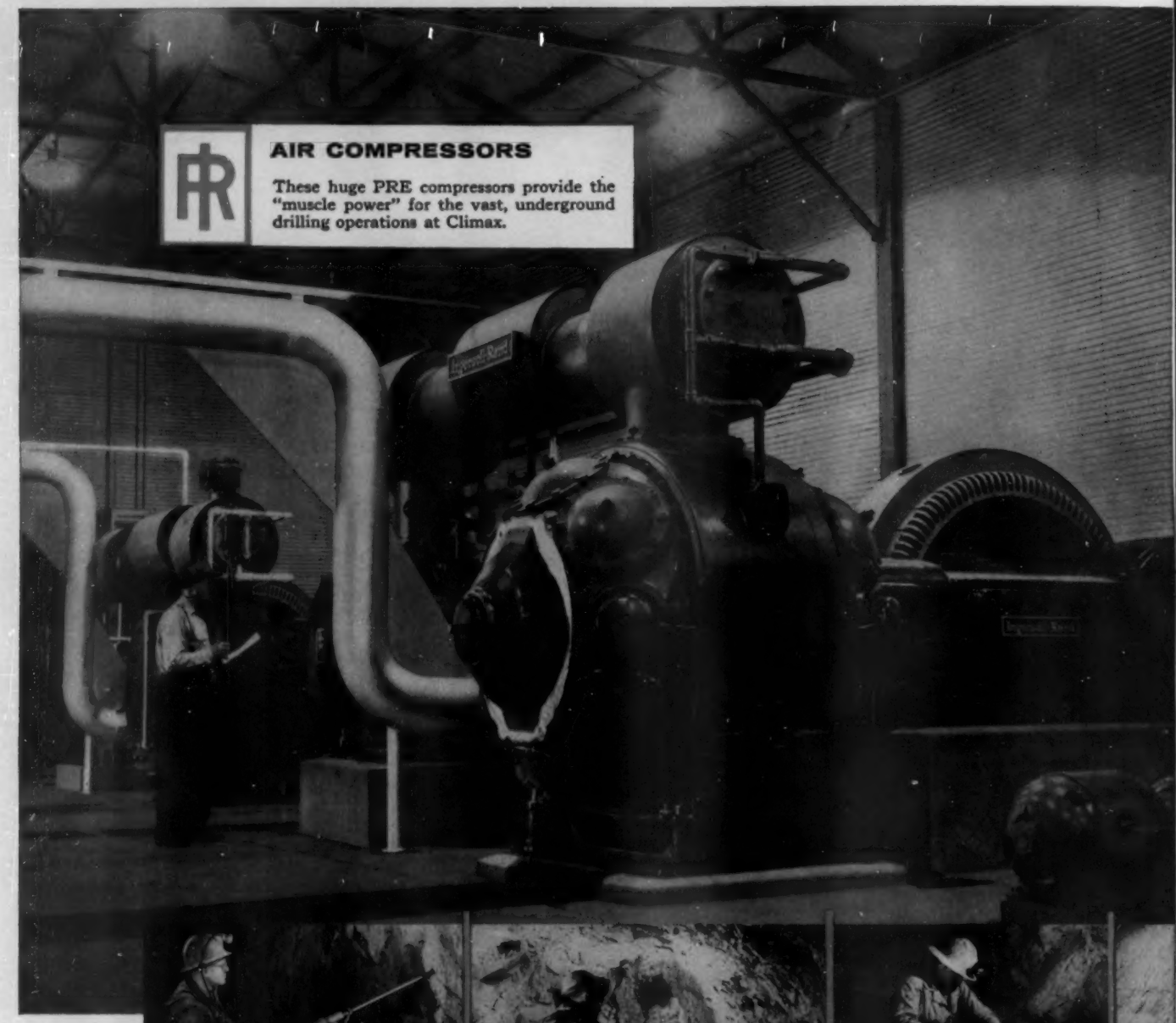
STEPHENS-ADAMSON MFG. CO.

37 Ridgeway Avenue, Aurora, Illinois • Los Angeles, Calif. • Belleville, Ontario

Engineering Division
Specialists in the design and manufacture of all types of bulk materials conveying systems.

Standard Products Division
A complete line of conveyor accessories including centrifugal loaders—car pullers—bin level controls—etc.

Sealmaster Division
A complete line of industrial ball bearing units available in both standard and special housings.



AIR COMPRESSORS

These huge PRE compressors provide the "muscle power" for the vast, underground drilling operations at Climax.

JACKDRILLS

Versatile, light-weight JR-38 Jackdrills save setup time and permit quick spotting of holes for drilling in practically any position.

STOPEHAMERS

These husky, hard-hitting stopers maintain consistently high drilling speed for all types of up-hole work.

JACKHAMERS

For down-hole and secondary drilling, the easy-handling J-40 Jackhamer is a big saver of time and effort.

Everything you need for drilling rock—from the compressor

DRILLING POWER AT Climax

North America's largest underground mine maintains top efficiency with I-R equipment

It takes plenty of *drilling power* to mine 8½ million tons of molybdenum ore per year. And to achieve this annual production on a profitable basis requires top efficiency of all equipment, from the cutting face all the way back to the compressor station.

That's why we at Ingersoll-Rand take pride in the vital role which I-R equipment has played in the successful operation of Climax Molybdenum Company's huge Climax mine. Here I-R rock drills, Carset Jackbits, air compressors, air hoists, bit shop equipment and centrifugal pumps helped to turn out 73% of all molybdenum produced by the free world in 1954.

CARSET JACKBITS

Carsets have become the standard of drilling speed and economy at Climax — because they maintain their high cutting efficiency for hundreds of feet of hole.

BIT SHOP EQUIPMENT

Cut-off machines, drill steel furnaces, sharpeners and draw furnaces keep drill steels in shape for top performance.

AIR HOISTS

These powerful utility hoists are widely used for hauling ore cars up grade and operating scraper equipment.

14-270

to the Carset Jackbit

Ingersoll-Rand

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Contributions to the Geology of North Dakota, by Students and Staff, Geology Dept., University of North Dakota, *North Dakota Geological Survey,* Grand Forks, N. D., Bulletin 28, $1.00, 156 pp., 1955.—Reprinted from *The Compass* of Sigma Gamma Epsilon, Volume 32, pp. 83-156. Illustrated.

Radioactive Minerals the Prospector Should Know, by David J. White, 3rd edition, revised and enlarged by Max Schafer, G.M.I. Short Paper No. 18, *Dept. of Geology & Mineral Industries,* 1069 State Office Bldg., Portland 1, Ore., 30¢, 21 pp., 1955.—New developments in the uranium industry in so far as they are pertinent to prospecting, especially in Oregon.

Electrical Resistivity Studies in the Kansas River Valley, by Daniel F. Merriam, Bulletin 109 part 7, 16 pp., 5 fig., 2 pl., October 1954. Mailing charge 10¢. **Preliminary Spectrographic Investigation of Germanium in Kansas Coal,** by John A. Schleicher and William W. Hambleton, Bul. 109 part 8, 12 pp., 2 fig., October 1954. Mailing charge 10¢. **Chemical, Petrographic, and Ceramic Properties of Four Clays from the Dakota Formation in Kansas,** by Norman Plummer, Ada Swineford, Russell T. Runnels, and John A. Schleicher, Bul. 109 part 10, 64 pp., 17 fig., 3 pl., December 1954. Mailing charge 10¢. **Evaluation of Acid Etching of Limestone,** by William Ives, Jr., Bul. 114 part 1, 48 pp., 1 fig., 5 pl., April 1955. Describes a technique for evaluation of overall properties and estimation of chemical composition of limestones. Mailing charge 10¢. **Coal Resources of the Marmaton Group in Eastern Kansas,** by Walter H. Schoewe, Bul. 114 part 2, 64 pp., 1 fig., 4 pl., April 1955. Mailing charge 10¢. **Magnetic Anomalies in Wilson and Woodson Counties, Kansas,** by William W. Hambleton and Daniel F. Merriam, Bul. 114, part 3, 16 pp., 3 fig., 3 pl., May 1955. Mailing charge 10¢. These bulletins are available from the State Geological Survey of Kansas, University of Kansas, Lawrence, Kans.

Soviet Scientific Journals. Beginning with the first 1956 issues complete English translations of several Soviet scientific journals will be available. Among them are sections of the *Proceedings of the Academy of Sciences of the USSR* (Doklady Akad. Nauk. SSSR). Prices quoted are for a year's subscription: Chemistry Section, $95.00. Chemical Technology Section, $30.00. Geochemistry Section, $20.00. Please direct all inquiries to Consultants Bureau, 259 W. 14th St., New York 11, N. Y. Translation service is also available for earlier list of Russian periodicals covering cement, ceramics, and chemistry.

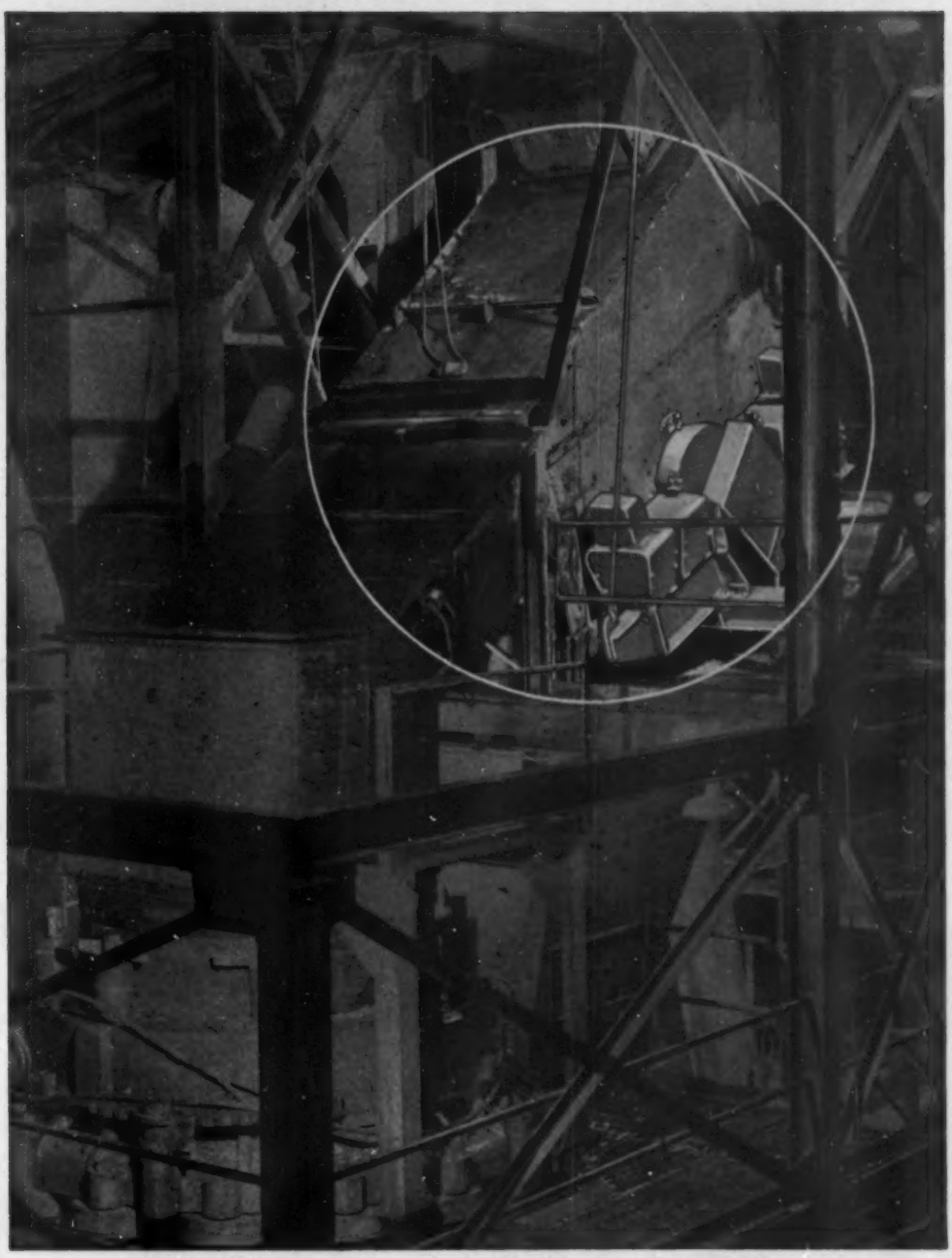
CLIMAX MOLYBDENUM COMPANY PLANT

EQUIPPED WITH

TYLER TY-ROCK SCREENS

Tyler Ty-Rock Screens precede the crusher at the Climax Plant of Climax Molybdenum Company.

The Ty-Rocks by-pass the undersize ore around the crushers to enable them to operate at peak capacity and efficiency.



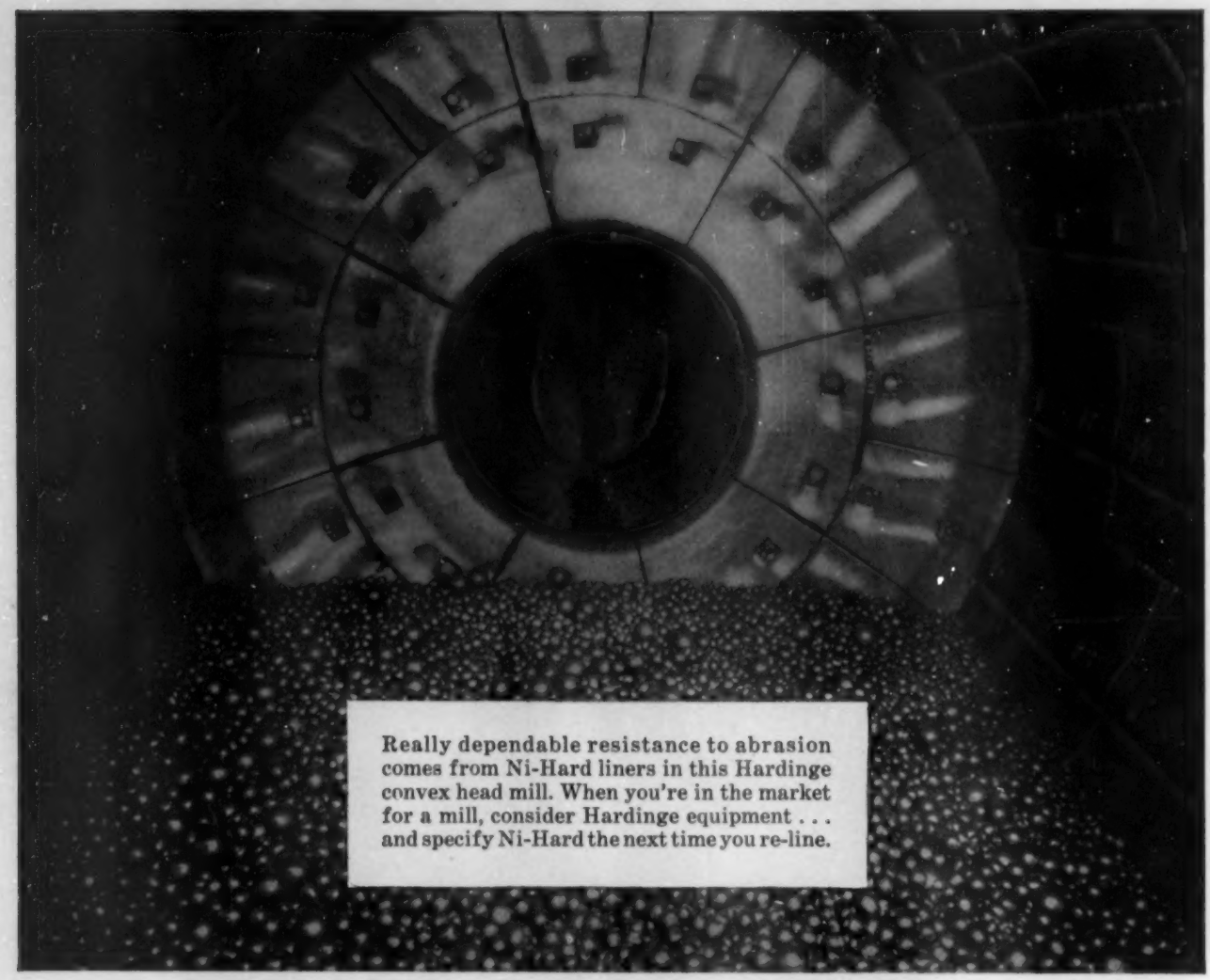
Circle shows one of the 5' x 9' Type F-900 Ty-Rock Screens ahead of the crusher.

THE W. S. TYLER COMPANY

CLEVELAND 14, OHIO, U. S. A.

CANADIAN PLANT—ST. CATHARINES, ONTARIO, CANADA

WOVEN WIRE SCREENS, HUM-MER ELECTRIC SCREENS, TY-ROCK and TYLER-NIAGARA SCREENS, TYLER STANDARD SCREEN SCALE SIEVES, RO-TAP and TY-LAB SIEVE SHAKERS



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...to extend liner life in their mills

Hardinge Company, Inc., of York, Pennsylvania, well-known producer of scrubbers, classifiers, cylindrical tube and batch mills, rod mills and other milling equipment, knows that satisfied customers mean more business. That's why Hardinge installs Ni-Hard liners as original equipment in their mills.

Ni-Hard liners actually double and triple the interval between relinings because they provide maximum resistance to abrasive wear. This resistance helps Ni-Hard liners maintain their contours and so mill more tons of ore per pound of wear.

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Ni-Hard shows greater strength and resistance to both impact and wear than does unalloyed white cast iron. So try Ni-Hard liners in your own mills . . . prove to yourself they can save you money.

Get the facts about Ni-Hard. Write us today.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

Sentinels of Safety Awards

Underground mines awarded trophies during the 30th National Safety Competition were: No. 5 Hill mine, Ploskonka Coal Co. (anthracite); Labuco mine, Alabama By-Products Corp. (bituminous); Zenith mine, Pickands, Mather & Co. (metal mines); No. 6 mine, U. S. Gypsum Co. (nonmetallic mines); Open pit receiving award was Mahoning mine, Pickands, Mather & Co., and quarry award went to the Thornton operation of Material Service Corp.

Industrial Minerals Developments

National Gypsum Co. shipped first gypsum rock from $6 million development at Halifax, Nova Scotia. Deposit is said to exceed 200 million tons . . . American Gilsonite, joint venture of Barber Oil Corp. and Standard of California, selected site near Fruita, Colo., for proposed plant to produce gasoline and coke from gilsonite mined at Bonanza, Utah . . . Continental Sulphur & Phosphate Corp. reports startup of 100-tpd solvent extraction sulphur plant at Sulphurdale, Utah.

Two More Plateau Uranium Mills

AEC contracts with Uranium Reduction Co. for a mill at Moab, Utah, and with Rare Metals Corp. of America for a mill at Tuba City, Ariz., bring number of mills built or building to 12. Controlling interest in Uranium Reduction is held by Charles Steen's Utex Exploration Co. which has contracted to sell output of Mi Vida mine to new mill. Foley Bros. Inc. will build plant and American Zinc, Lead & Smelting is to manage it. The Tuba City plant, being built by Rare Metals Corp., will treat ores from Cameron, Ariz. area.

OTHER URANIUM DEVELOPMENTS found Kerr-McGee Oil Industries opening Plateau's ninth mill at Shiprock, N. M.; Mines Development Inc. scheduling spring 1956 completion for tenth processing plant at Edgemont, S. D.; and the AEC opening an ore buying station at Globe, Ariz., on July 5. . . . Large scale strip mining program in Utah announced by Continental Uranium involves moving 2½ million yd at Rattlesnake mine near Moab. . . . Looking abroad, Atlas Corp. and associates are widening uranium holdings by buying into North Australia Uranium Corp. which has property in the Alligator River district of North Australia. . . . Climax Molybdenum Co. in joint venture with Jaffe Associates is investigating uranium leases in Karnes County, Texas, about 40 miles southeast of San Antonio. Reports suggest large tonnages of relatively low grade ore.

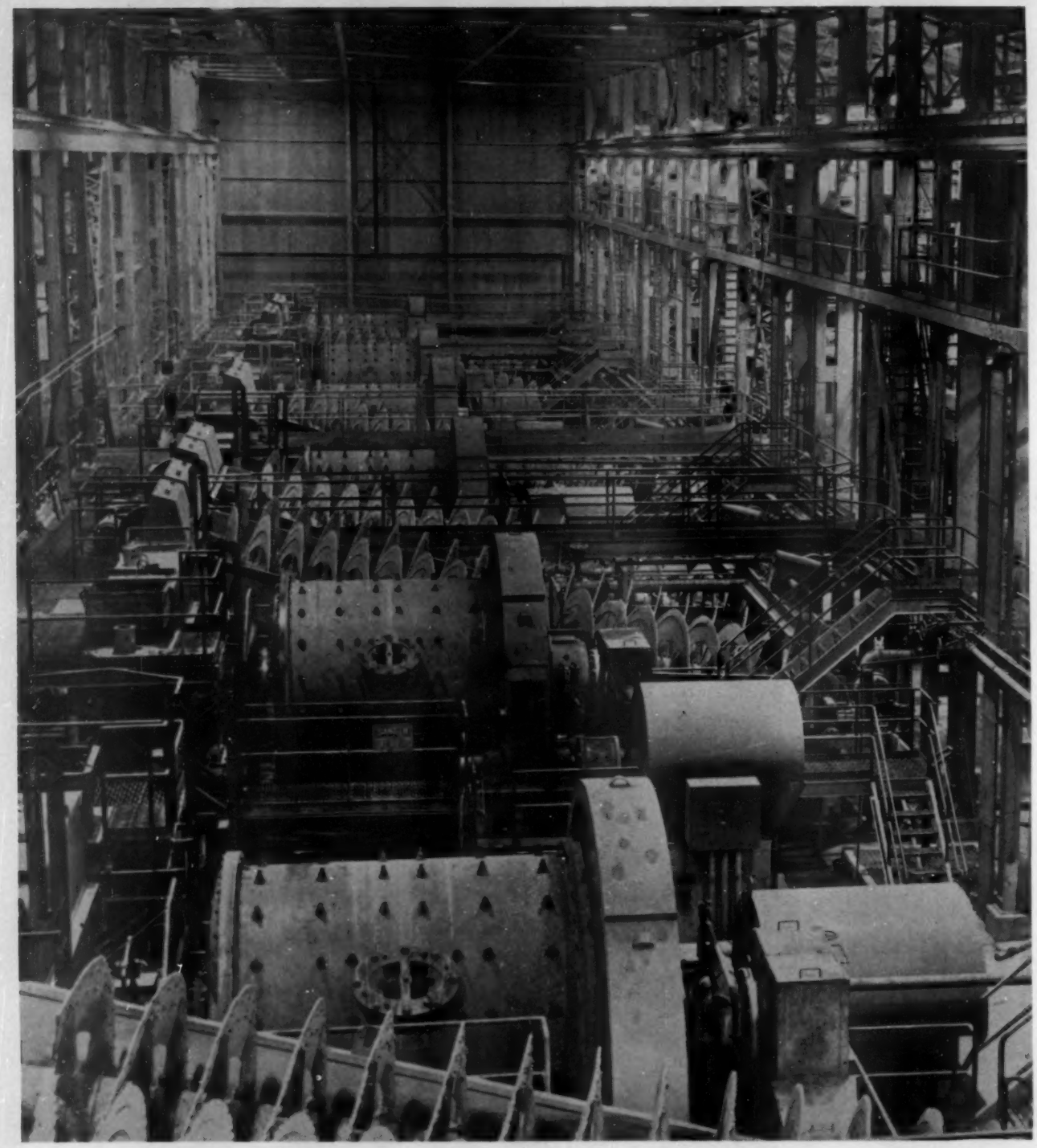
Zinc Activity in Wisconsin

American Zinc, Lead & Smelting Co. acquired leases on 370 acres of zinc property in southern Wisconsin from Cuba City Mining Co. and in another transaction took over the 800-tpd capacity milling facilities, mining leases, and equipment held by Vinegar Hill Zinc Co., also in southern Wisconsin.

Beneficiation of Lakes Ore Gains

Of 62 million tons of iron ore shipped in 1954 from U.S. and Canadian properties in the Lake Superior region almost 20 million tons, about 32 pct, was beneficiated. Taconite and jasper production passed million-ton mark.

At Climax it's MARCY



Six 78" Akins Duplex Classifiers and six 9' x 9' Marcy Grate Discharge Ball Mills in the new Climax Mills numbers 3 and 4.

and AKINS

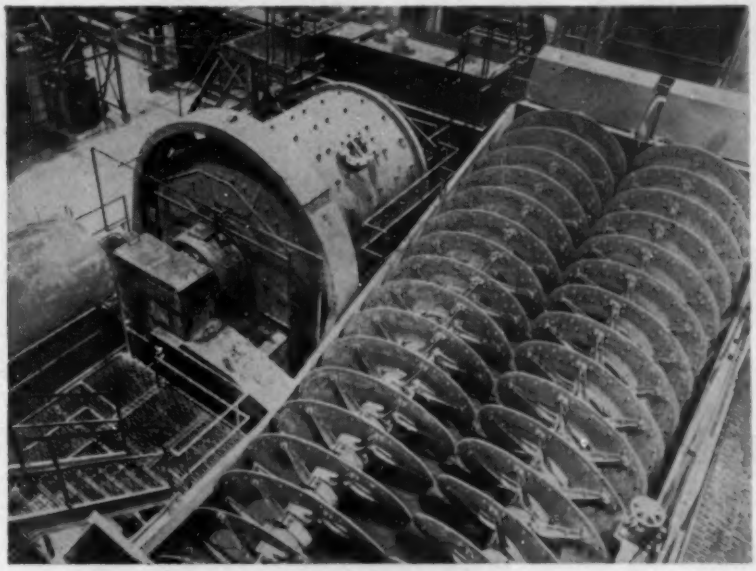
Since 1929 The Climax Molybdenum Co. has placed 11 orders for Marcy Mills and Akins Classifiers—convincing evidence of dependable, cost-cutting mechanical and metallurgical performance. The equipment ordered includes the following:

MARCY MILLS

2 – 5′ x 20′ pebble mills
4 – 8′ x 20′ pebble mills
1 – 9′ x 7′ ball mill
12 – 9′ x 9′ ball mills

AKINS CLASSIFIERS

1 – 45″ simplex
1 – 36″ simplex
1 – 16″ simplex
1 – 12″ simplex
15 – 78″ duplex
1 – 78″ simplex
2 – 60″ duplex
7 – 48″ duplex



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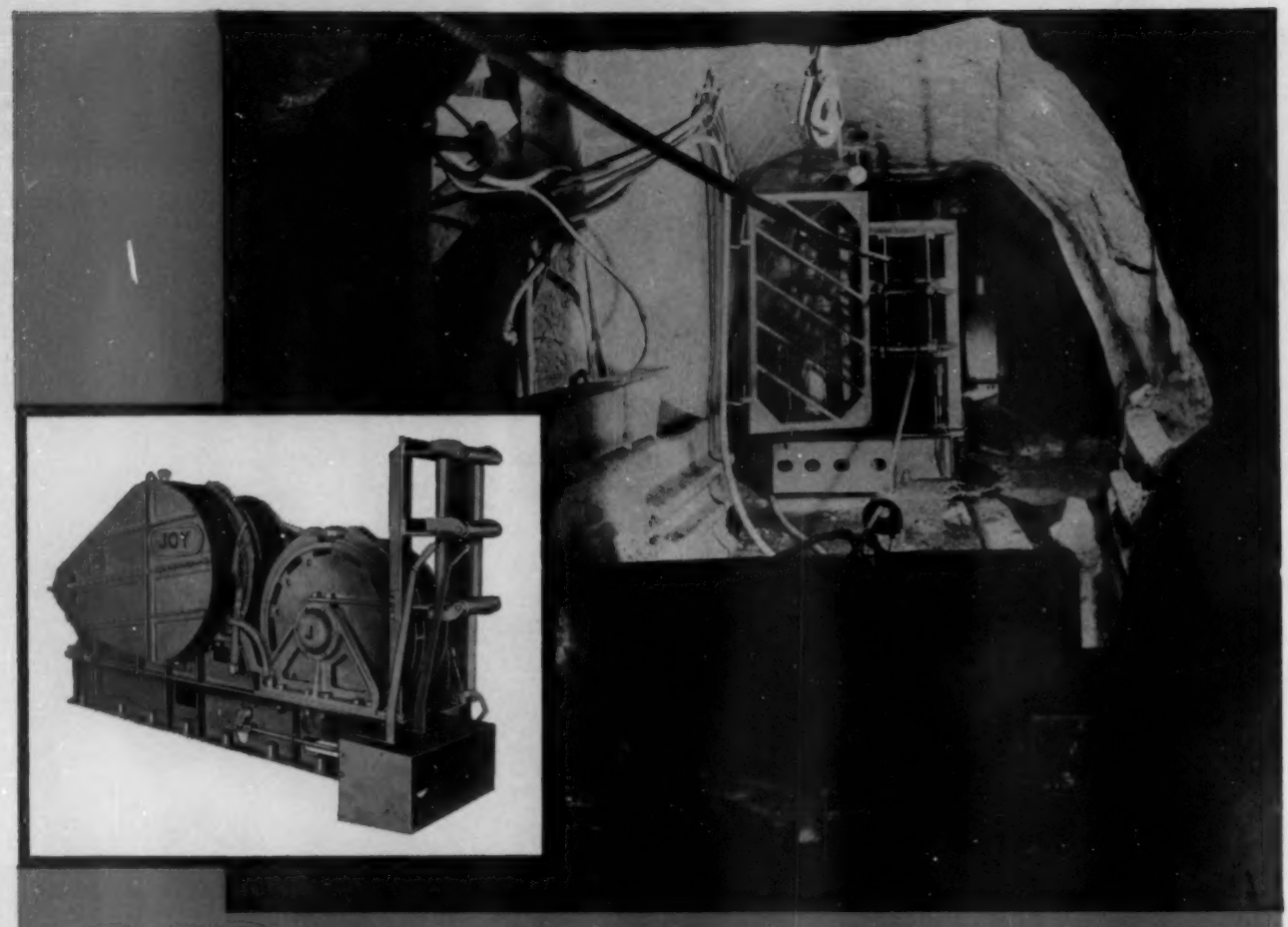


BIG JOY EQUIPMENT is the PAYOFF at CLIMAX

A mining system built around the use of high-capacity, heavy-duty scraping equipment has been the payoff at Climax. Block caving into slusher drifts, which will accommodate a 6′ folding scraper, has resulted in a saving of up to half of the cost of gravity-chute ore collection methods previously employed.

The 150 HP Joy XT-221, a large tandem two-drum slusher with chain drive, is used at Climax for this high-capacity slusher operation. Many of these heavy-duty machines work on a three-shift basis yet with remarkably low maintenance. During the loading of the first 3 million tons of ore from the Storke Level at Climax by 23 Joy XT-221 Slushers, *the only repair charge was for clutch band linings.*

The Joy XT-221 is the largest model in a complete line of rugged scraping equipment expressly built for heavy underground duty. The line ranges from the 5 HP Model S-221 to 150 HP units such as the one illustrated above in a Climax drift, and includes models which will solve most scraping problems. For complete information on Joy Slushers, write ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

Consult a Joy Engineer

for AIR COMPRESSORS, ROCK DRILLS, CORE DRILLS, HOISTS and SLUSHERS, MINE FANS and BLOWERS

W&D M5737

JOY

WORLD'S LARGEST MANUFACTURER OF UNDERGROUND MINING EQUIPMENT

INCO Excavates Crusher Station at Levack Mine

For the first time in its operations, the International Nickel Co. has used blasthole methods to excavate a giant underground crusher station at the Levack mine in the Sudbury district of Ontario. The huge chamber, big enough to hold two average 8-room houses, is on the 2650-ft level.

Blasthole Method Saves Time

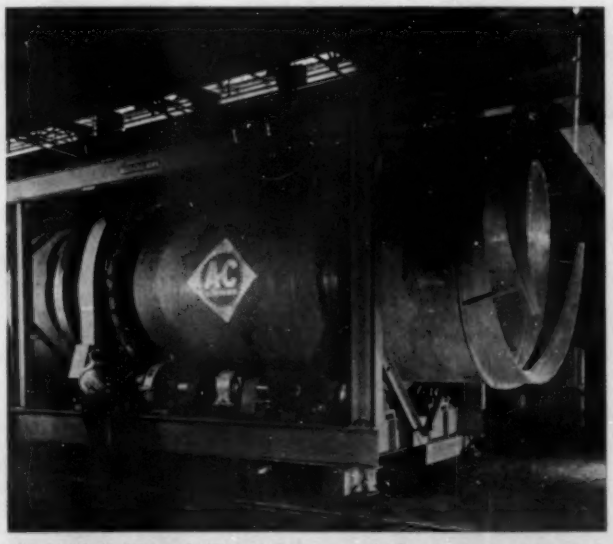
The crusher station, concreted throughout, required an opening 70 ft high, 26 ft wide, and 68 ft at its longest point.

A raise 7x11 ft was driven from the loading pocket at 2825 level up to the base of rail on 2650 level, then a 7x7-ft drift was opened from No. 2 shaft station to connect with the raise. The full dimensions of the crusher station at the base of rail were silled out by square-setting. After a second cut, the back was rock bolted and heavy steel ceiling beams were installed. With the square-sets as a working platform, concrete was poured for the roof and walls, after which the sets were removed.

Then, with longhole tungsten carbide bits, the part of the crusher station below the 2650 base of rail was all drilled off. About 175 holes were required, varying in depth from 10 to 49 ft. Drilling totaled more than 5600 ft.

As slashing into the raise progressed, the excess broken rock was pulled directly into the skips at the 2825 level loading pocket. When blasting was completed, the entire opening for the station below base of rail was filled with broken rock. As the level of the muck was pulled down, using a slusher when required, steel beams were installed for the first and second floors of the station. Finally, the balance of the broken rock was drawn off from the opening and the walls were concreted.

By adopting this method of excavation in preference to previously accepted mining practices Inco was able to save more than two months in construction time.



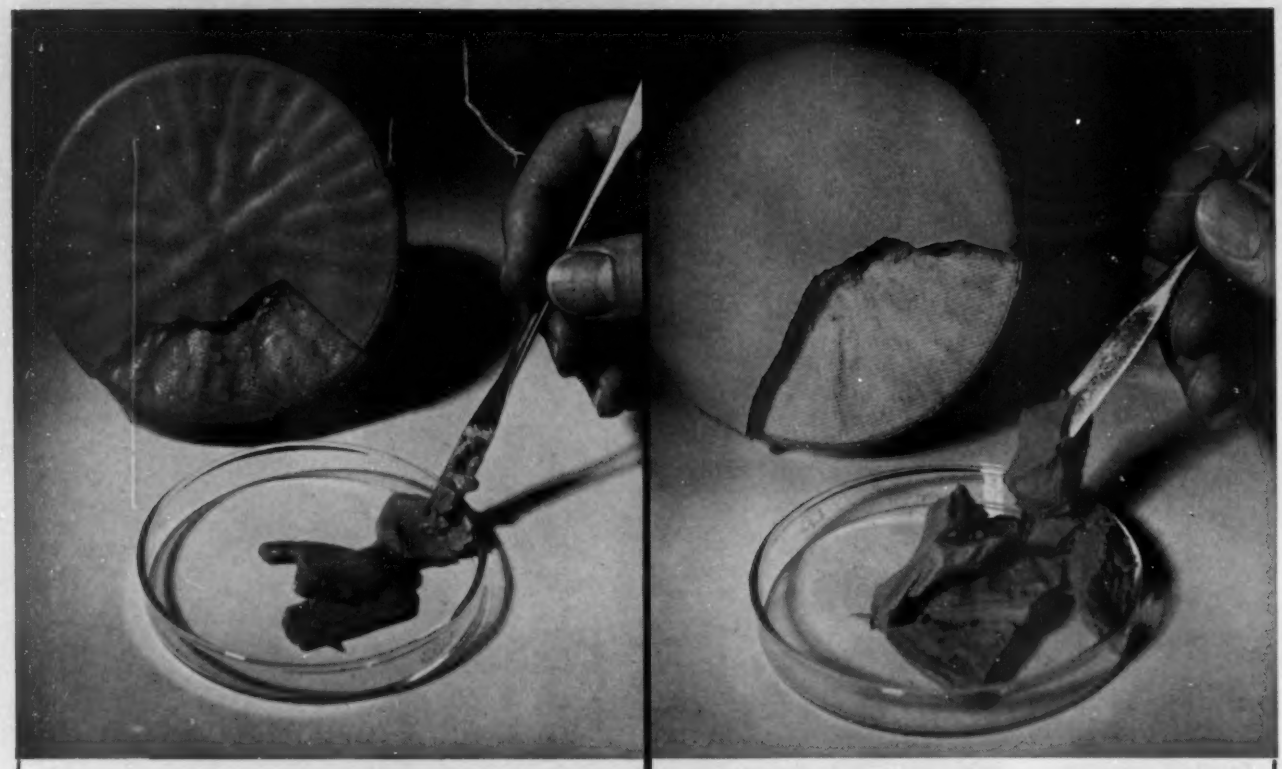
This 9x30-ft, 37-ton balling drum is one of 18 units being shipped to a Minnesota taconite plant by Allis-Chalmers Mfg. Co. Each drum will have capacity of 30 to 45 tph. Drum shell is lined with expanded metal and an inch of concrete. A reciprocating cutter bar maintains an additional lining of adhering concentrate. The cut spiral distributor spreads the balls over a vibrating screen.

Felix E. Wormser, Asst. Secretary for Mineral Resources, is shown presenting a Joseph A. Holmes Safety Assn. Medal and Certificate of Honor for heroism to Navy Lt. Billy Scroggins who donned portable oxygen breathing apparatus and entered a salt mine at Winnfield, La., to rescue shuttle-car operator Julias Smith who had been overcome by gas. Rescue was lieutenant's first time underground at a mine.

Separan 2610

DOW

GREATLY IMPROVES FILTRATION



Above picture shows thin cake formed on filter with untreated solids. Cycle includes 15-second cake formation and 45-second drying time.

During the same cycle, a much thicker cake is formed by treating with 0.15 lb. of SEPARAN 2610 per ton of dry solids present.

New flocculating agent speeds up filtration and settling rates, brings many other improvements to liquid-solid separations

THE DOW CHEMICAL COMPANY
Dept. TS 789C-1, Midland, Michigan

Please send me information and a trial sample of SEPARAN 2610.

Name_____

Company_____

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Prove to yourself the advantages of Separan* 2610 in filtration.

1. Increased cake size
2. Decreased cake moisture and better washability
3. Easy to handle and less dusty cake
4. Less material loss in filtrate
5. Effective over wide pH range

Prove to yourself the advantages of Separan 2610 in settling.

1. Up to 40 times faster settling rate
2. Increased overhead clarity
3. Less materials loss in overhead
4. Reduced cost in acid and alkaline media
5. Increased plant capacity

SEPARAN 2610 is highly effective in these industries:

- Uranium
- Clay
- Borax
- Cement
- Alum
- Potash
- Foundry Sand
- Coal
- Phosphoric Acid
- Iron Ore and Taconite
- Industrial Water, and Waste
- Miscellaneous Metals

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DOW

Britain Searches for Undersea Coal Reserves

A start has been made on one of the most spectacular mineral boring operations ever undertaken in Britain, according to British Information Services. A steel tower built after the fashion of a coastal fort has been anchored in the Firth of Forth, a mile and a quarter offshore from Kirkcaldy, Scotland. Operating from a working platform about 50 ft above sea level, at high tide, drilling experts will bore nearly 2000 ft and bring up cores of the strata to assist the National Coal Board in its planning program for the new Seafield colliery.

The overall aim is to prove that this undersea area contains the largest remaining virgin field of coal in the United Kingdom.

6 Billion Tons of Coal

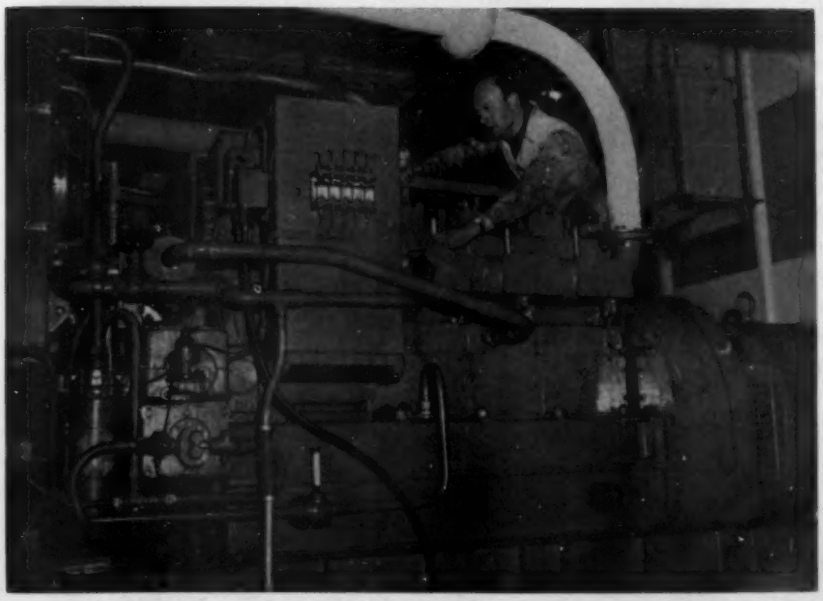
In a way there is a "heads I win, tails you lose" touch about the project. It would be almost impossible to find any mining engineer or geologist who would be prepared to assert that the coal seams are not continuous all the way across the Forth from Fife to the Lothians, but what is not known is the true picture of the levels and the actual depth and thickness of the seams, and that is essential for forward planning of high output collieries involving expenditure of up to $28 million per unit.

The prize which the Coal Board is after in this undersea field, the first of several similar areas to be bored, is, according to H. R. King, production director of the Scottish Divisional Board, 6 billion tons of coal.

Unit is shown grounded at 10:20 pm after being lowered by hand owing to a power fault. Built like a coastal fort, tower is 1¼ miles offshore from Scotland.

Reducing that to understandable terms it means 6000 years output for the largest colliery in the Scottish coalfield or, put another way, the equivalent of 250 years production for every colliery in Scotland.

The cost of the tower is $700,000. Although it is being used initially in the Firth of Forth similar work will be undertaken off the coast of Durham in northern England and elsewhere.



Electric installations on the National Coal Board's Sea Boring Unit.

The mining picture in the Firth district at present is that collieries on either shore are working seawards in the direction of the center of what is thought to be a vast basin-shaped field.

The borehole now being put down will be drilled in some 70 ft of water. A second hole will be put down nearly 3 miles off the coast.

The team operating the rig will be virtual prisoners for days, and perhaps weeks on end. The tower was designed by engineers who were responsible for establishing nearly 50 sea forts during the war, some of them 30 miles out to sea.

It is floated to its drilling position and lowered on to the sea bottom. The legs, of tubular steel, are fixed to a base of cruciform design. The whole structure, therefore, rests evenly on the seabed.

Can Withstand Gales

Preliminary investigation and examination of the bottom were carried through with the aid of the latest scientific instruments and by visual inspection by divers. When lowered into position, the tower is capable of withstanding an 80-mph gale and waves measuring 30 ft from crest to trough.

The X-shaped girder base consists of two heavy steel box sections 163 ft long. The working deck, 50 ft above the water level, carries a drilling rig that rises a further 54 ft into the air.

THIS AMSCO® LIP TAKES A SHARPER BITE

. . . chews out full loads at normal power

The lip juts way out where it easily bites up—and delivers—the full yardage of rock or earth. It's a sharp *extension* of the dipper, with fanned teeth—for fast, easy penetration. The dipper digs out a heavier load without strain on the shovel . . . even requires less power, and prolongs life of all parts.

This Amsco lip lasts a long, long time, because it's made of the toughest steel known—manganese steel—the metal that work-hardens to fight off wear by impact and abrasion. Lip replacement is simple, when necessary, keeping downtime short.

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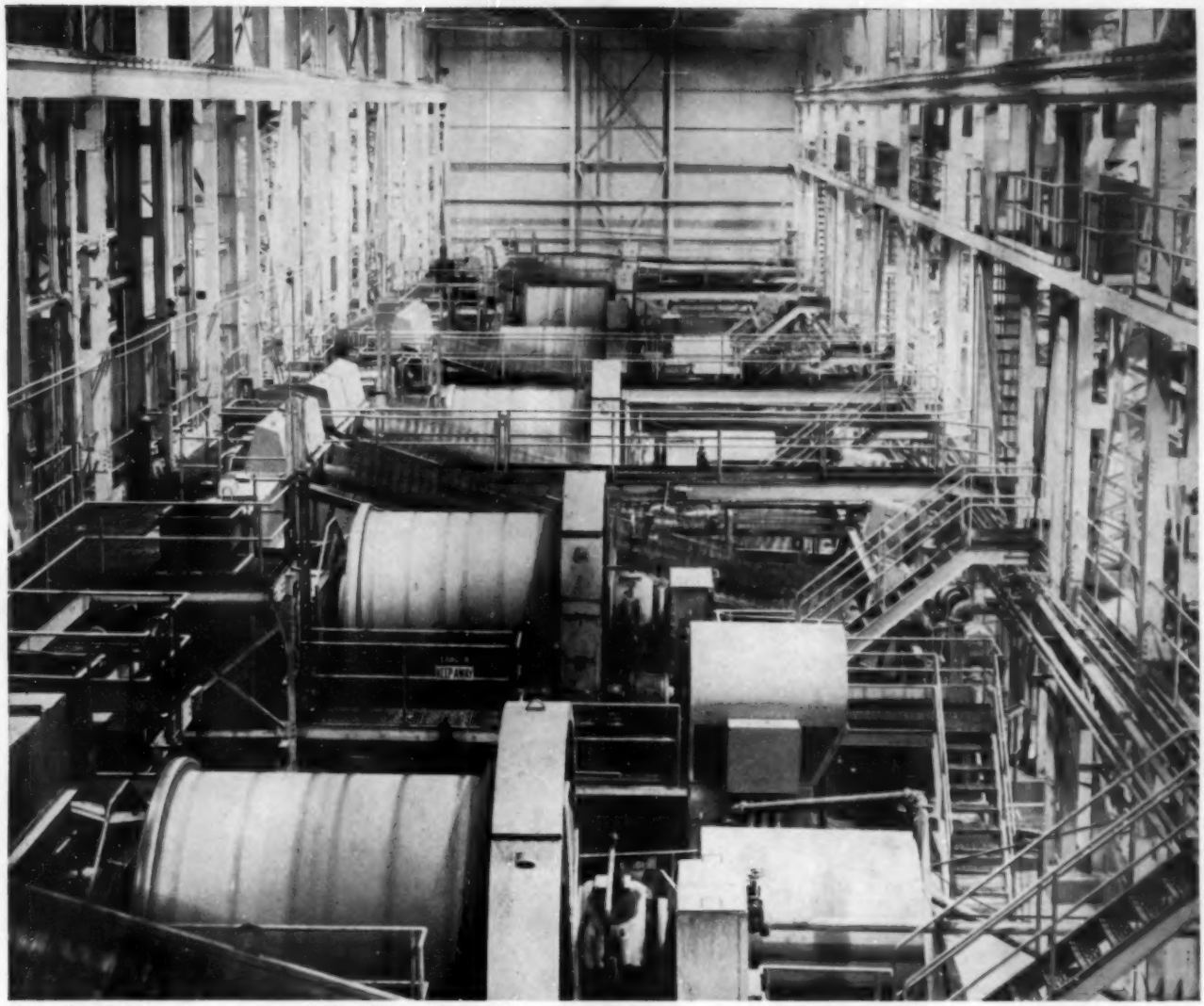

Photo showing exterior view of the ball mills used in the Climax Molybdenum Company's No. 3 and 4 mill

Partners in Progress

Climax Molybdenum Company and CF&I have been partners together in the phenomenal expansion of Western industry Today Climax has expanded their operations, as has CF&I, to the extent that their products are being sold throughout the world

CF&I is proud of its close association with the Climax Molybdenum Company in its expansion and modernization program.

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Largest Copper Producer in the Far East Treats 4000 t.p.d. with 100% Cyanamid Reagent Combination

As the new Toledo Copper Project of Atlas Consolidated Mining and Development Corporation swings into full-scale production, a major step in rebuilding the Philippine Mining Industry will have been taken.

With a capacity of 4000 t.p.d. the new Toledo mill will be by far the largest copper producer in the Far East. At peak production the mill will produce 200 t.p.d. of copper concentrates assaying 24% Cu.

For the preliminary copper float AEROFLOAT® 238 Promoter and AEROFROTH® 80 Frother are used to produce a high-grade concentrate running 26% Cu. A bulk float follows, using a reagent combination composed of AEROFLOAT® 25 Promoter, AERO* Xanthate 301, AERO* Promoter 404 and AEROFROTH® 80 Frother. Bulk concentrates are then reground and refloated to produce a second copper concentrate and the pyrite product. In the selective flotation circuit, reagents include AERO® Brand Cyanide, AEROFLOAT® 238 Promoter, AEROFROTH® 80 Frother and lime.

Combined copper concentrates containing over 92% of the total copper in the feed are presently being shipped to Japan for smelting. Recovery of molybdenite from the copper concentrate is now under study, and work is also underway to expand plant capacity to 6000 t.p.d.

In the development of treatment methods for Toledo ore, Cyanamid Engineers have been privileged to work closely with A. Soriano y Cia., General Managers and Consultants for Atlas Consolidated. We will welcome the opportunity to work with you on your beneficiation problems and to provide your reagent needs from Cyanamid's complete line of metallurgical chemicals.

*Trade Mark

PHOTO 1.

Crushing p[illegible] entrance to open pit mining operation on the north side of the [illegible] Toledo on the island of Cebu, P.I. Crushing is in two stages to ⅝". Crushed ore is conveyed across the river to the grinding and flotation plant.

PHOTO 2.

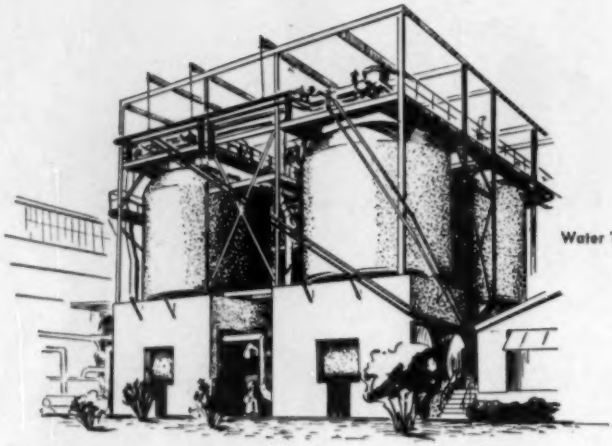
Grinding of Toledo ore is also in two stages. The first stage employs 8′ x 6′ ball mills in closed circuit with rake classifiers. The second stage includes 20″ cyclones, 6′ x 10′ ball mills and bowl classifiers.

PHOTO 3.

Interior of Toledo mill showing Japanese-built 56″ flotation machines in the roughing circuit. Much of the mill equipment was salvaged from pre-war Philippine mills and rebuilt.

AMERICAN Cyanamid COMPANY

MINERAL DRESSING DEPARTMENT 30 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK



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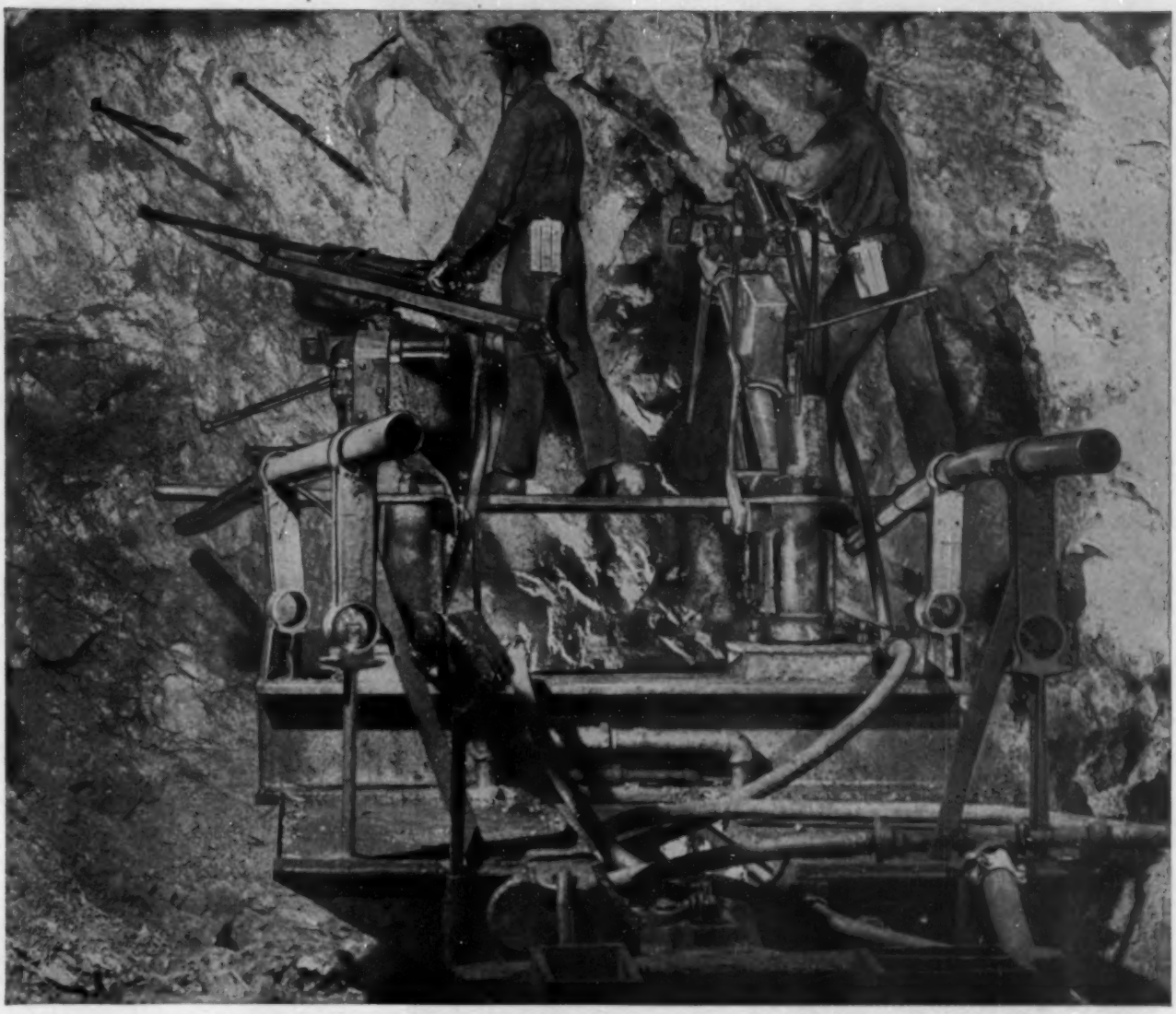

Gardner-Denver CF93 Drifters at work for Climax.

At Climax Molybdenum . . . of course! . . . Gardner-Denver Quality

In common with many of the world's great mining enterprises, Climax Molybdenum uses Gardner-Denver equipment. The reason . . . Gardner-Denver quality that assures high efficiency and low maintenance. Gardner-Denver equipment in operation at Climax:

Model RB94P STOPERS **Model SFH99 DEEPHOLE DRILLS**
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Write for further information on the complete line of Gardner-Denver rock drills, deep hole percussion drilling equipment, and other mining equipment.

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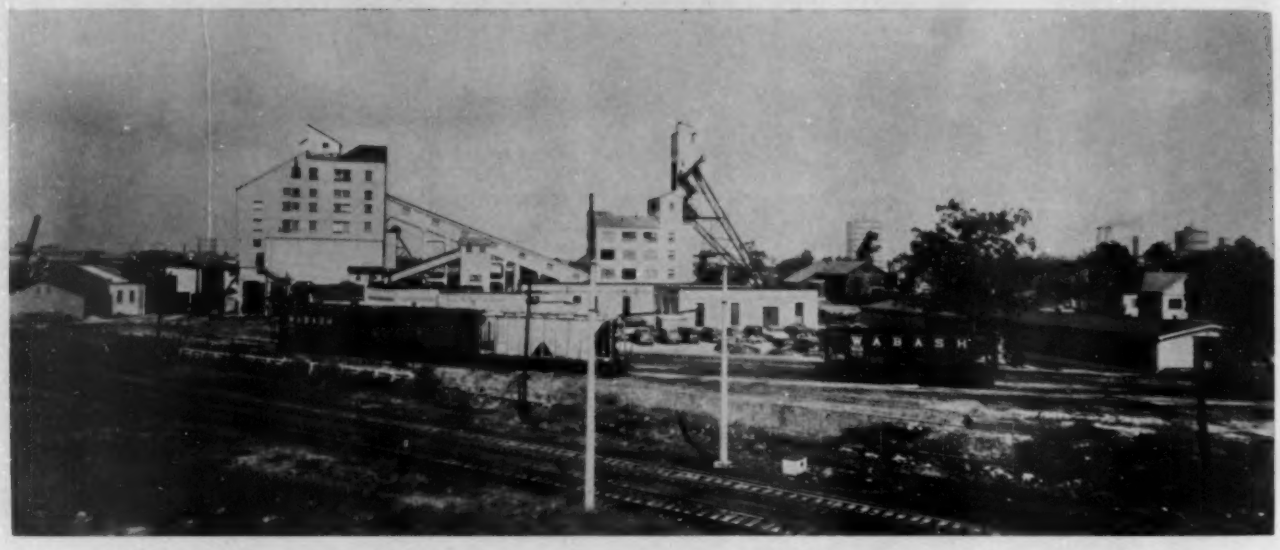
Salt City Beneath the Motor City



General surface view of Detroit mine, whose underground operations lie below about 300 acres of the Motor City, Detroit. The mine lies at a horizon 1137 ft below these buildings, which are near Fort St. and Sanders Ave. in Detroit.

Some 300 acres of Detroit industry is underground. It all started around 1906 when the first shaft for salt mine operation was sunk in the village of Oakwood, Mich., now part of the city of Detroit. Production started in 1910 and in 1913 International Salt Co. of Scranton, Pa., took over the mine.

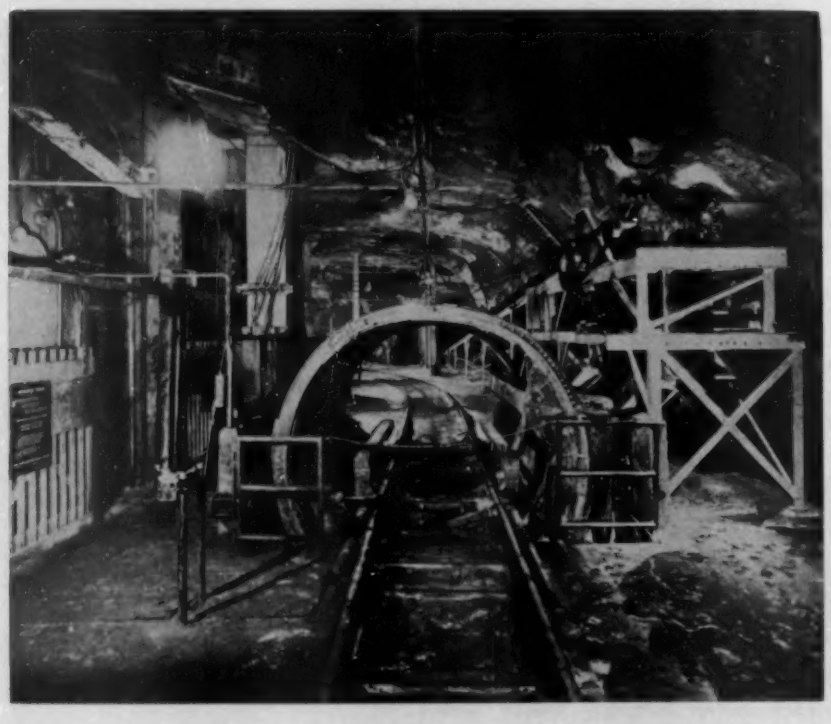
Today the mine workings go down to 1137 ft under the southwest part of the city. Two vertical shafts service the operation. One 16-ft diam shaft, of circular construction, reinforced with concrete and lined with brick, is used for hoisting rock salt and transporting men in and out of the mine. A part of the shaft is partitioned to serve as an air duct to the mine workings, with 80,000 cfm of air forced through a blower fan for ventilation. The second shaft has twin 42-in. diam tubes. Double-deck skips haul men and materials.

The seam worked at the Detroit mine is a comparatively flat one, averaging 26 ft in thickness. Mining is somewhat similar to coal operations. A room-and-pillar method is used, leaving 50 to 60 ft wide roof supports after rooms ranging from 50 to 60 ft wide and 22 ft high have been mined out. The pillars are mined later by driving passages.

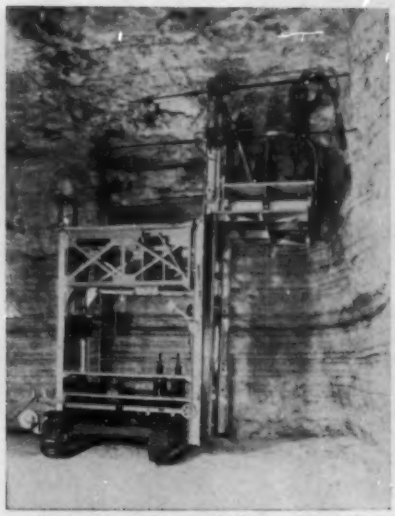
Machines employed are almost identical with those in underground coal mining. The cutter bar of the undercutting machine is forced into the salt to a depth of about 10 ft and the machine cuts across the entire face of the room. A 6-in. kerf or slot extending back under the salt for a depth of 10 ft is left.

The face across the entire room is drilled from floor to roof with rotary electric drills. Holes are 1½-in. diam and about 10 ft deep. Blasting with dynamite takes place after midnight when most of the crew have left the mine. The blast is electrically detonated.

Marion electric shovels load the salt into 15 to 20-ton trucks which take the material to a large single roll primary crusher. From there the product is belt conveyed to an underground crushing and screening plant for classification into various commercial sizes of rock salt and for storage. Salt not stored underground goes on a main conveyor belt for 1¼ miles to the hoisting shaft. The hoist is electrically driven by two 500-hp motors. On the surface further crushing, screening, and classification takes place.



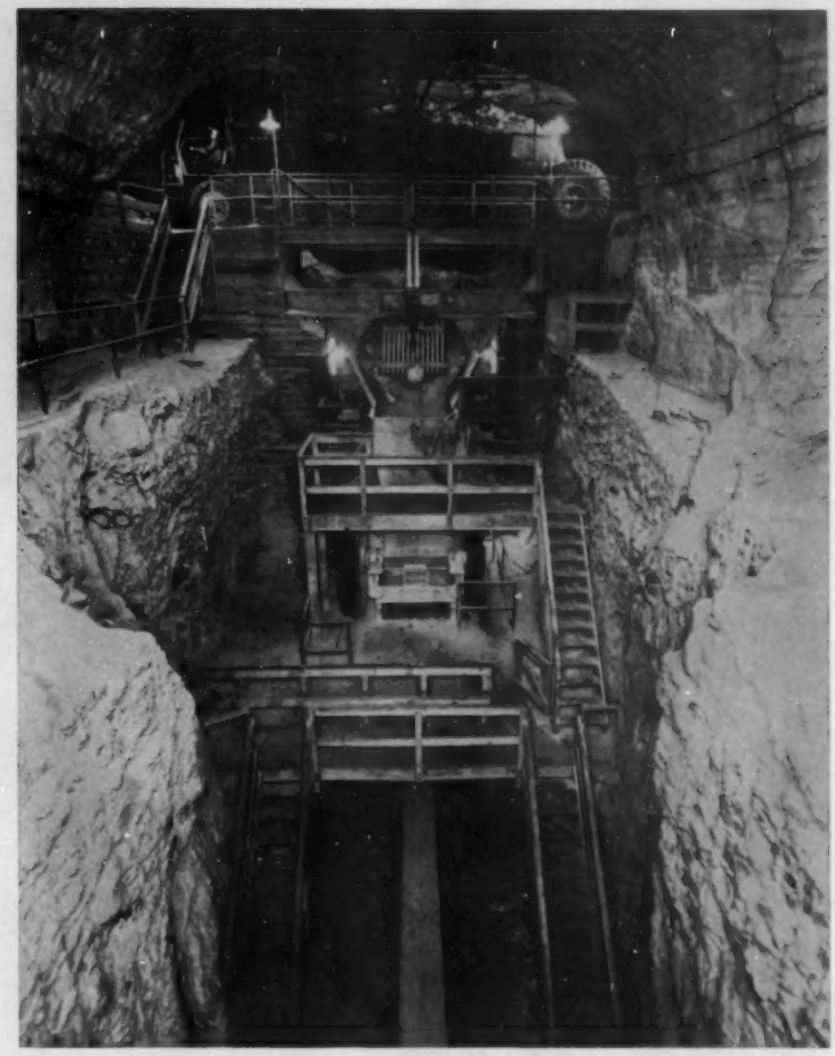
At foot of shaft conveyor belt from underground storage point discharges crushed salt into 9-ton skips. Rotary cardump in foreground was used until conveyor was installed.



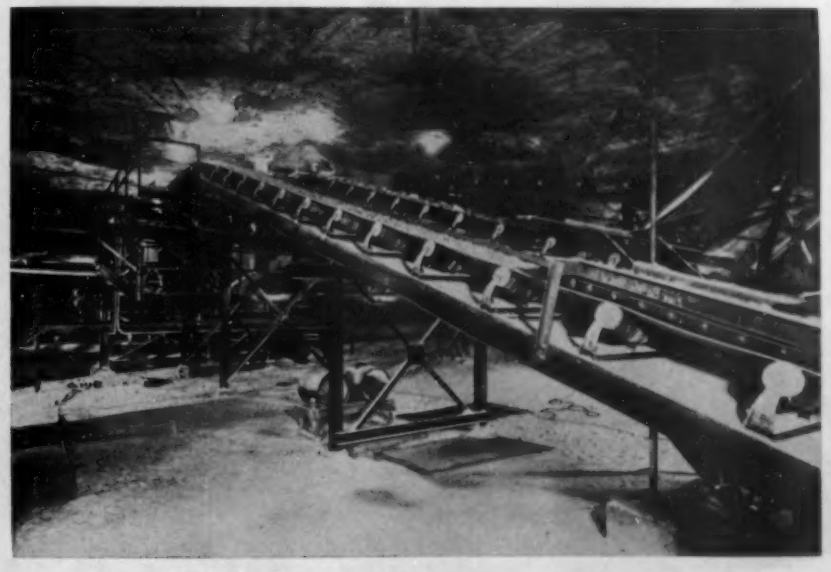
Four rotary electric drills on this self-propelled carriage drill the entire face following undercutting operation.

First step in the mining operation is undercutting with endless chain cutter-bar. Slot is 6 in. high by 10 ft deep.

After each blast about 900 tons are loaded out per room. Bulldozer is cleaning up before loading by 1½-yd Marion electric shovels.



Euclid truck is dumping into primary single-roll crusher that reduces salt to —8 in. Crushed material then goes to preparation station, also underground.



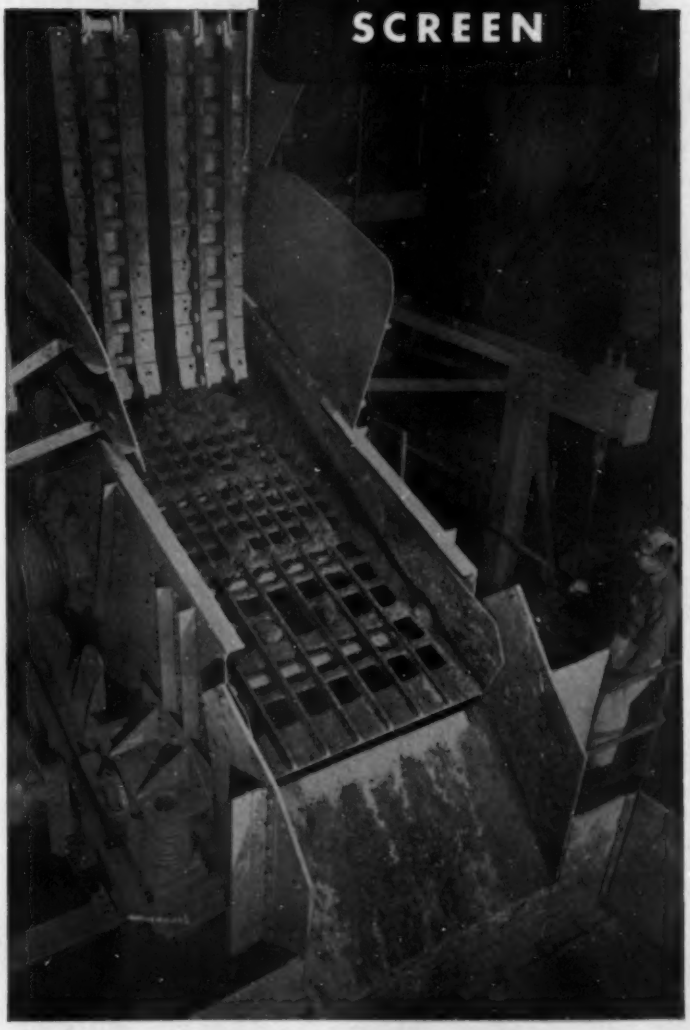
At this site picking and secondary crushing operations are carried out. Rock is first picked out at this preparation station before salt is reduced to —2 in. and placed on conveyors to final crushers.

PROVED ON ONE OF THE

Toughest Testing Grounds

...THE MESABI RANGE

New **Run-of-Mine SCALPING SCREEN**



Single pieces weighing as much as four tons . . . hundreds of pounds of sticky material adhering to screen body . . . large volume requirements. These are the demanding conditions under which this screen is setting new performance standards.

Here are some of the many features which enable this screen to meet severe duty with *minimum maintenance:*

Extra-Large Bearings (largest ever installed in an A-C screen) withstand punishing loads. Bearing life is extended, replacement less frequent.

Simplified Two-Bearing Mechanism reduces maintenance time and cost.

Cartridge Mechanism can be pulled out after merely removing sheave and four bolts.

Sturdy Channel Construction features 12-inch I-beam deck support.

Soft Support Springs provide smooth, balanced operation. No need to remove adhering material. Practically no vibration transmitted to building.

For information on this extra-heavy-duty screen and other Allis-Chalmers screens applicable to your operation, see your A-C representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

***Designed to Team Up With Primary Crushers* to handle the toughest job on any mining flow sheet.**

ALLIS-CHALMERS

A-4761

A FEW weeks ago a young fireball from West Virginia came to New York City with the express purpose of selling some three dozen executives in the metalworking and clothing industries on his state. The young fireball was William C. Marland, former coal miner and now Governor of West Virginia. The reason he has embarked on a campaign that will consume a major share of his remaining time in office is a desire to see his constituents less dependent on the fluctuating bituminous industry of his state.

Bituminous coal had one of its best periods in 1948, when some 115,000 miners were employed. Today only about 60,000 are employed in the state industry. West Virginia is the leading bituminous producer and coal production is the state's top industry. While the mines are recovering from one of the worst depressions in years, many West Virginians have been forced to leave the state for employment. So, Governor Marland is out to persuade other industries to come to his state. He is after chemical and woodworking industries as well as metalworking and apparel.

The thing that started the sales campaign on the part of the 37-year old executive was an industrial survey made by Arthur D. Little Co. of Boston. The survey proved that an overbalanced economy had been brought about in the state by concentration of a few industries.

The chemical industry in West Virginia has been growing. One area of particular significance is south of Moundsville, along the Ohio River. Several large plants have located there in the past six years because of the discovery of brine beds, easily available fuel, and cheap river transportation. But the chemical industry alone has not been able to halt the population decline brought about by a drop in mining. West Virginia showed a 3 pct population drop from 1953 to 1954—one of only two states in the country to show such a loss.

Governor Marland doesn't know if his drive will work. "It's new and may be a great success but we want to see how it goes," he commented.

Paul Newsome, of Arthur D. Little, doesn't feel that way. He was encouraged by a series of conferences in New York with industrialists. "They knew why they were being invited and they know what we're trying to do."

To anyone's knowledge, this is the first time an industrial campaign of this type has been tried. A lot of people think that the former miner and son of a miner who still carries a United Mine Workers union card is the man to make it go.

◆◆◆◆

THE Senate Interior and Insular Affairs Committee has unanimously approved a bill to increase Federal purchases of tungsten, manganese, chromite, mica, asbestos, beryl, and columbium-tantalum-bearing ores and concentrates. The bill aims at giving production of those minerals a shot in the arm.

Sponsoring the bill are Republican Senators Barry Goldwater of Arizona, George W. Malone of Nevada, and Thomas E. Martin of Iowa, and Democrats Carl Hayden of Arizona, James E. Murray and Mike Mansfield of Montana, W. Kerr Scott of North Carolina, and Alan Bible of Nevada.

Senator John J. Williams, Delaware Republican, has attacked the bill on the grounds that it is a $750 million "raid on the Treasury." He made public a letter from Arthur S. Flemming, Defense Mobilizer, who stated that domestic supply of the metals and minerals "has so improved that there would be no justification in the name of national defense" for the measure.

Senator Williams is of the opinion that the bill represents "one of the boldest raids on the Federal Treasury that has been proposed in recent years." He contended that the bill commits the Government to the purchase of the entire production of the next 12 years of the minerals at a specified price "far above the prevailing domestic and world markets."

He also argued that the bill allows the prices of the minerals to be raised by the Government but at no time can they be lowered. At deadline it looked as if Senator Williams had won, and the bill was dead, at least for this session of Congress.

◆◆◆◆

WORLD industrialization is a long way from being an established fact but the trend is set. Free World industrial production expanded 3½ pct per year since 1937 and 4½ pct yearly since 1950. It has been estimated that growth will continue by at least 3 pct per year.

It's quite obvious that as the Free World becomes more industrialized the demand for raw materials must rise. It has been predicted that the requirement for raw materials valued at about $46 billion in 1950 will rise to about $80 billion by 1975 to 1980, based on 1950 prices.

While industrialization is of prime importance to every geographical area in the world, it is especially significant to South America. Along with the rise in demand for raw materials the international trade in materials is expected to increase from $27 billion to $50 billion by 1975 to 1980. And because nations that export raw materials can look forward to a rapidly expanding market, the South American countries may be in an especially good position. The 20 republics must steadily increase basic material production to get the foreign exchange they need to support projected expansion of their industrial base.

But in the recent past South America has failed to take full advantage of her raw materials potential. While cotton, iron ore, lead, and zinc production climbed, copper, tin, manganese, and wool exports dropped. Latin American petroleum production has also failed to maintain the pace established by the rest of the world in the past few years.

One of the channels for possible exploitation by South American countries is the diversification of raw material exports. Countries dependent on one or two commodities usually find themselves involved in year-to-year fluctuations. It will take a monu-

mental amount of capital to swing increased production and imports. The republics are going to need a great deal of help from outside for the job.

◆◆◆◆

MOST economists will go only so far out on a limb when making predictions. Just before the point of no return they slide back to safety via the use of phrases beginning with if, but, or maybe.

Right now, economic prognostication is especially risky. The nation is enjoying one of its best years. In fact, there is a chance that it will outdistance 1953, top year of U.S. economic history. All the indicators point upward and according to Commerce Secretary Weeks as long as the country has labor peace the current rate of prosperity should continue.

Several widely separated factors appear to have some importance in the total evaluation. One of the more obvious ones can be seen in the roads crowded with new cars. One can drive several miles on a busy Sunday and see almost nothing but 1954 and 1955 models. Many expect automobile buying to drop in the second half of the year. It almost has to. Quite possibly new car buying will not start to swing up again until next spring. If that upswing is delayed it must have an effect on the total economy. Automobile manufacturing reaches deeply into various other segments of the productive life of the country.

The construction of new dwelling units has been going at a fantastic pace. New records have been set every month. It seems unlikely that the pace can be maintained indefinitely. One indication that it will not is that selling prices on older houses have started to dip somewhat and some resistance is being met in disposing of these houses. In addition, more closely concerning new units, some Congressmen are beginning to question the wisdom of the easy financing that has been possible up to now for both veterans and nonveterans.

Another item to be watched is Government spending. The Cleveland Trust Co. in its *Business Bulletin* sees no letdown in Federal expenditures. Government spending is often tied in with political expediency. Should the economy take a dip toward the beginning or middle of 1956, it can be expected that the Democrats will start talking depression. (It *is* an election year.) To counter any possibility that the opposition will be able to reap victory from a mild economic decline, the present administration might be forced to resort to a Democrat trick and prime the pump a bit.

The crucial period may come around Christmas 1955 or slightly afterward. The drop in consumer buying that comes in January will not be significant in itself. If this year continues as it has, department stores can look toward a seasonal buying spree that will practically strip the counters. But if the usual spring buying recovery is not immediately forthcoming, or shows signs of weakness, it could be an omen for the remainder of the year.

However, one thing must be borne in mind. Right now, the country is more solidly able to withstand minor fluctuations in its economy than at any period in its history. The current boom is hardly a spurious one. People have real money to spend, money based on the greatest production era in world history.

Among the indicators that display most graphically the strength of the current situation are the new orders received by manufacturers, especially for durable goods. Last year, when business in general was somewhat unhappy, the new orders started to lead the parade. Production rose and unfilled back orders piled up in the books. The same thing is happening today—when production is already high.

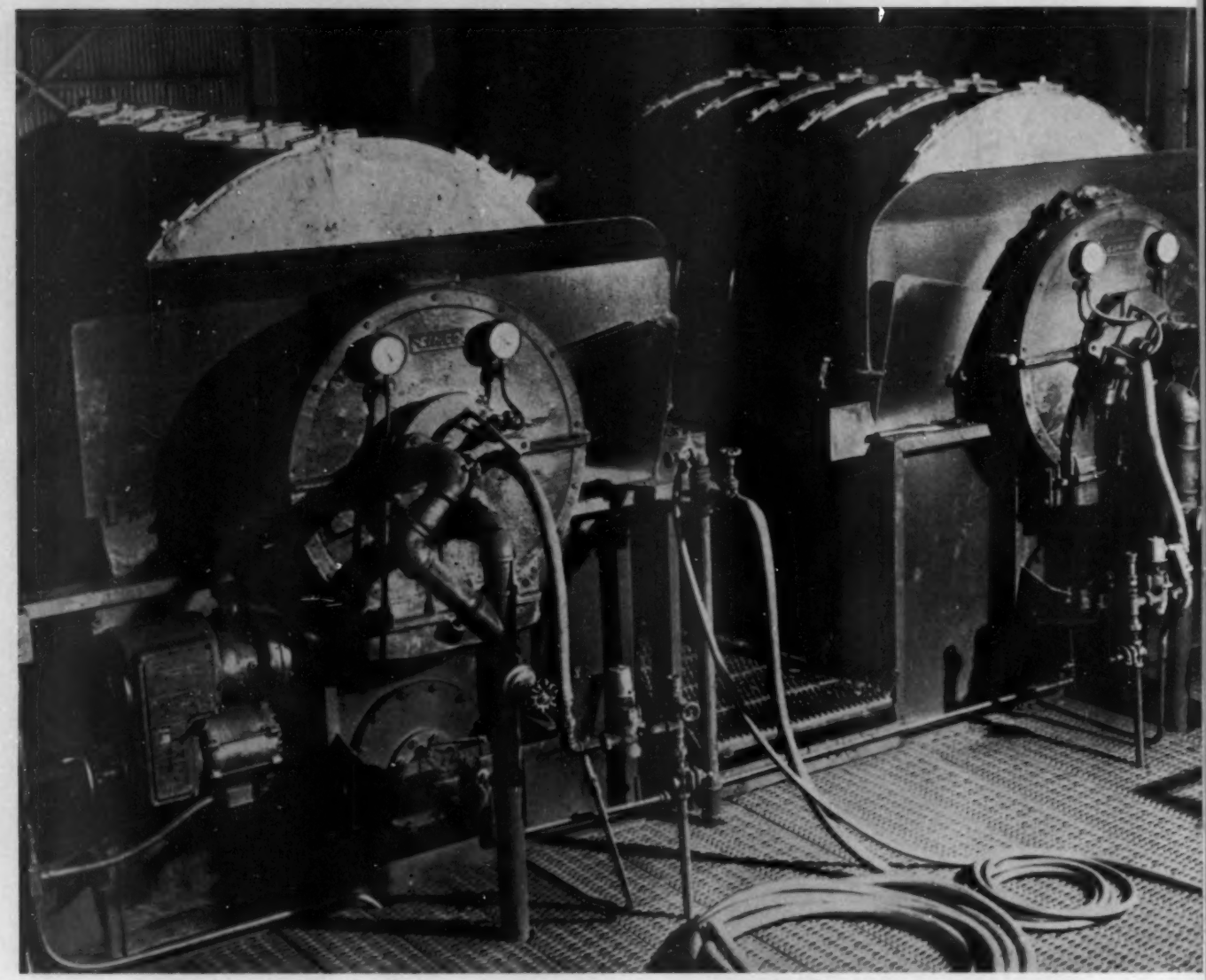
Another good sign is the climb in the average weekly hours worked in factories. There has also been a jump in new business incorporations. And, conversely, there has been a decline in the amount of liabilities involved in business failures.

Can the advance started last fall continue? The Federal Reserve index of industrial production climbed without interruption from 123 to 136. At this rate it would reach 150 by next December. That may be a little too much to expect. As was noted previously, automobile and new dwelling production are likely to ease off. The good thing to note is that these two changes have been anticipated and should they occur few if any would be caught unawares—an indication of a healthy and intelligent situation.

One other factor looms up but its significance is slightly evasive. Installment buying is way up since the end of World War II. But so is personal income. It is difficult to determine whether installment buying is approaching a state of imbalance with income. One must treat almost every case individually. A survey conducted by the University of Michigan shows that 45 of 100 families had no short-term consumer debt other than the usual noninstallment charge accounts. At the other end of the scale 6 of every 100 families were paying out 30 pct or more of their incomes, after taxes, to finance companies. It becomes dangerous when debt overloads the income. One of the things that tempts people into this pitfall is the no-down-payment easy-terms routine so prevalent today.

One thing can be safely ascertained today. The present rise should continue through December 1955. After that it should slow down somewhat and quite possibly dip. But the nation is in good shape financially and much the same mechanisms that started the current rise will prevent anything like a severe economic setback. The efficacy of unemployment insurance, veteran benefits, old age pensions, and savings has been proved.

One thing is sure, and that is that the precise prediction of the state of a free economy over the long pull is somewhat beyond the powers of even the most highly skilled economists. It has been said that economics is both art and science. Perhaps it is an art when it misses the boat by a bit and a science when it hits the target on the button. If nothing else, economic prediction serves to alert the wise to what could happen and start them thinking of what they can do to keep their heads above water in a given set of circumstances.



REDUCE COSTS AND

Eimco equipment helps to reduce costs and increase production at Climax Molybdenum Company property at Climax, Colorado.

This is one of the world's great mines, more than two miles above sea level and with the record for high tonnage production on a per man shift basis.

One of the pieces of equipment used to obtain high tonnage production is the Eimco Folding Scraper. This scraper was developed at Climax by Climax people and its use permits loading ore into cars at a rate of 16 tons per minute from one slusher drift.

In the development headings, dependable Eimco air-powered 12B, 21 and 40H RockerShovels load out the broken material to keep development on schedule.

Along the main haulage ways, especially at loading stations, cleanup is maintained by a trolley type electric powered Eimco 40HE RockerShovel. This loader has a power swing to clean the full width of the drift and the trolley permits it to transport itself quickly around the mine.

In the mill, Utaloy liners are among the brands

INCREASE PRODUCTION

employed as mill linings. Utaloy liners are molybdenum — chrome alloy steel, carefully heat treated. Marquenching in molten salt assures uniform hardness throughout liner sections up to 8 inches in thickness.

Eimco Agidisc filters are at work dewatering the concentrate in the mill. This recent installation handles 350,000 lbs. of concentrate per 24 hour day. The Eimco filters operate automatically and require only periodical inspection. They require less than 50% of the floor space used for the equipment they replaced, have reduced the moisture content in the cake by 33%, and increased the filter rate by more than 15%.

Eimco equipment will help to increase production and reduce costs in your mine and mill. Specialized equipment to meet your requirements in loading or filtration has been developed to meet the needs of industry. Call an Eimco engineer to help you specify the equipment best suited for your job. There is no obligation.

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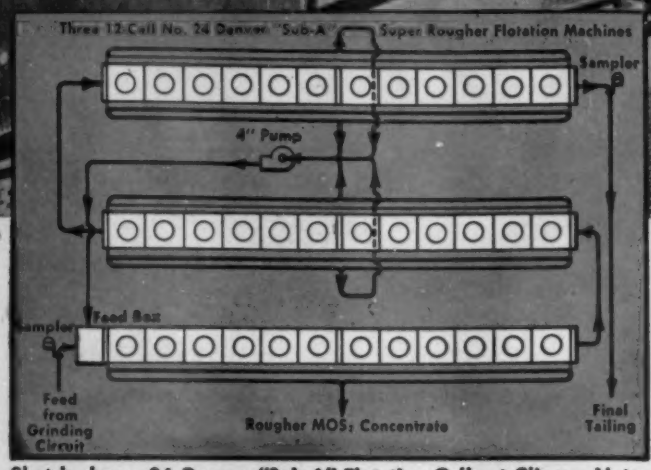
Denver "Sub-A" Flotation Machines are used at Climax to recover "moly."

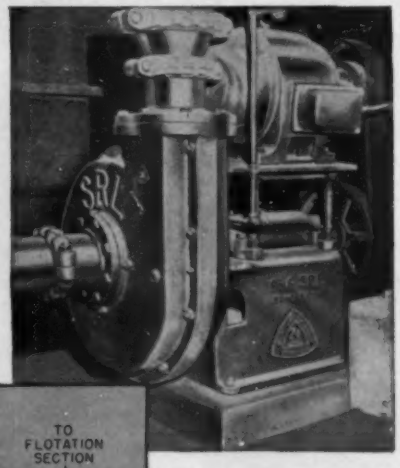
DENVER "SUB-A" FLOTATION at CLIMAX

Denver Equipment Company is proud of the part that Denver "Sub-A" Super-Rougher Flotation Machines are playing in the success of Climax Molybdenum Company and other mining companies throughout the world. Denver "Sub-A" Machines are the world's leader and serve in every important area of the world.

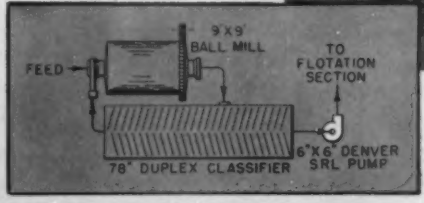
DECO manufactures a complete line of milling equipment in addition to maintaining one of the world's most complete ore testing laboratories. Information on any mineral recovery problem or machine will be supplied on request.



Sketch shows 36 Denver "Sub-A" Flotation Cells at Climax. Note how flotation feed enters at lower left and flows through all 36 cells. Concentrates from banks No. 2 and No. 3 are returned to bank No. 1 (photo above). Final rougher concentrate is removed from bank No. 1.



Overflow from classifier is pumped to the flotation section through a Denver SRL Pump. These pumps are rubber lined to resist abrasion. Pumping efficiency is high and power requirements are low.



"The firm that makes its friends happier, healthier and wealthier"

DECO FLOTATION ENGINEERS — DENVER EQUIPMENT 24 HOUR SERVICE COMPANY

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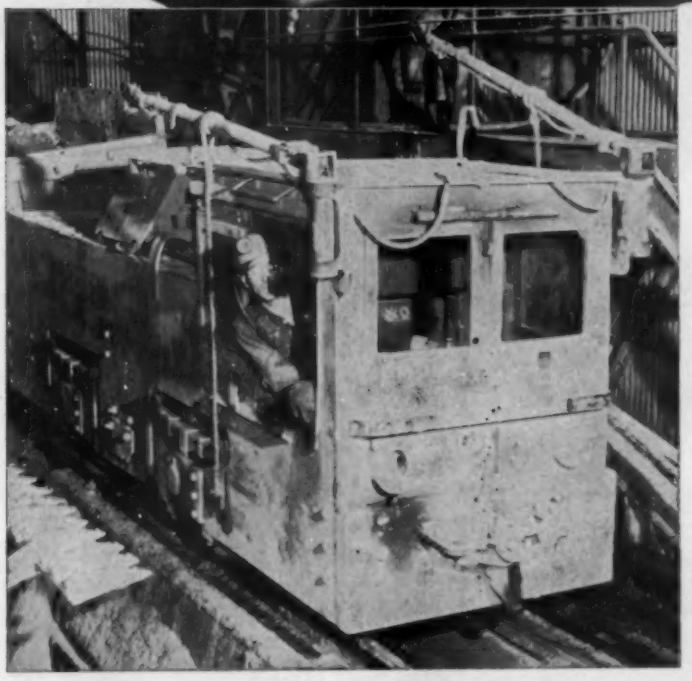


CLIMAX

is the largest underground mine in the world.

ATLAS LOCOMOTIVES *have pulled most of the ore produced from this mine.*

THE ATLAS CAR & MANUFACTURING CO.

Since 1896

1100 Ivanhoe Road **Cleveland 10, Ohio**

SYMONS®

CRUSHERS and SCREENS

have been serving CLIMAX MOLYBDENUM COMPANY for over 25 years

This Nordberg Machinery dependably serves CLIMAX in its expanding production of molybdenum

- 60-IN. SYMONS PRIMARY GYRATORY CRUSHER
- TWELVE 7-FT. SYMONS CONE CRUSHERS
- TWENTY-FIVE SYMONS ROD DECK SCREENS

High up in the Rockies in Colorado is the miracle mine of modern times. Its immensity marks an achievement unequalled in the industry and its glamour parallels to a marked degree the romance which has woven its way through mining history. Here, two and one-third miles above the level of the sea is located Climax Molybdenum Company . . . presently the largest underground mining operation in North America and the largest producer of molybdenum in the world.

As the percentage of pure molybdenum present in molybdenite ore is generally low and as it is usually found disseminated through hard, crystalline rocks, the importance of a successful method of reduction crushing can be appreciated. *As early as 1927,* Climax recognized the inherent advantages of Symons Cone Crushers. Later, after extensive testing of all types of screens, Climax standardized on the Symons Rod Deck.

Today, the greatly expanded Climax production depends to a large degree on Nordberg Machinery . . . a 60-inch Symons Primary Gyratory Crusher . . . TWELVE 7-ft. Heavy Duty Symons Cone Crushers . . . and TWENTY-FIVE Symons Vibrating Rod Deck Screens.

For at CLIMAX . . . *as in all of the great ore and industrial mineral operations the world over . . .* NORDBERG MACHINERY is the outstanding preference among leading producers for processing great quantities of finely crushed and screened product at low cost.

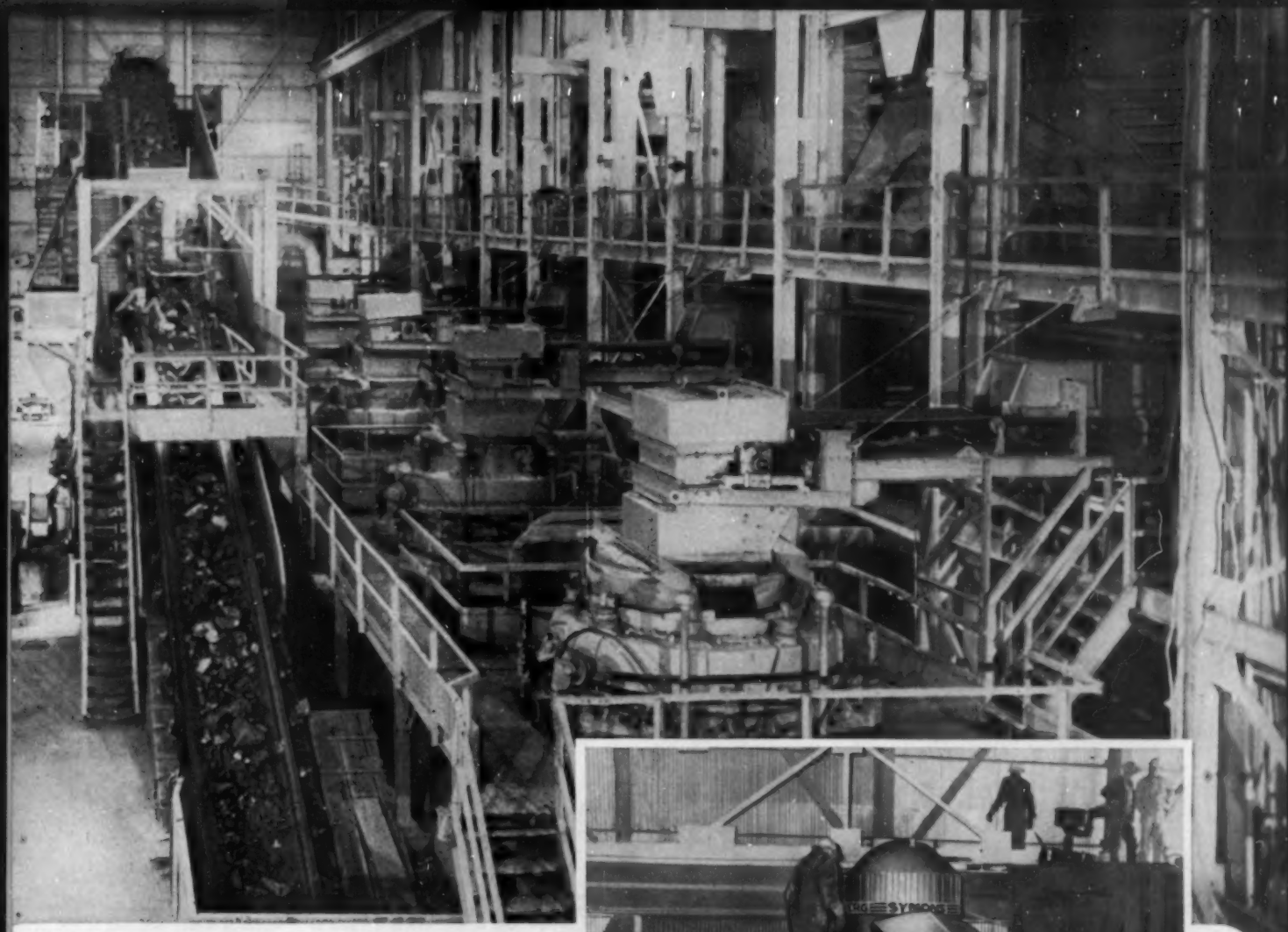
Write for further information on the machinery *you* need for the profitable reduction of ores and minerals.

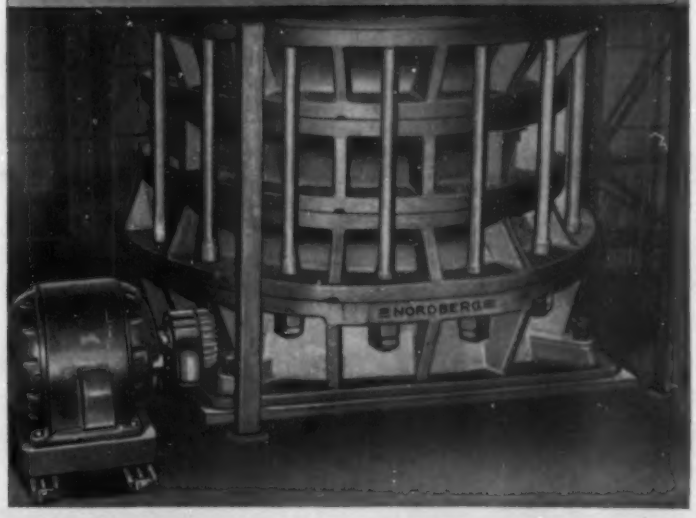
Record of Symons Crusher and Screen Installations at Climax:

SYMONS CRUSHERS

1927—1 4′ Standard	1953—1 7′ Short Head
1930—1 5½′ and 1 7′ Standard	1 60″ Primary Gyratory
1933—3 5½′ Standards	
1935—2 7′ Short Heads	**SYMONS SCREENS**
1936—2 7′ Standards	1941—5 Rod Decks
1 7′ Short Heads	1942—5 Rod Decks
1937—2 7′ Short Heads	1943—5 Rod Decks
1952—1 7′ Short Head	1953—5 Rod Decks

NORDBERG MFG. CO., Milwaukee, Wisconsin





- ***Above:*** **Five of the 12 Symons 7-ft. Heavy Duty Cone Crushers installed at Climax.**
- ***Right:*** **60-in. Symons Gyratory Crusher used for primary breaking at the new Storke Level plant at Climax.**
- ***Below:*** **Two of the 25 Symons Vibrating Rod Deck Screens installed at Climax.**

C655

NORDBERG MACHINERY

NORDBERG

SYMONS SCREENS NORDBERG

MACHINERY FOR PROCESSING ORES and INDUSTRIAL MINERALS

NEW YORK • SAN FRANCISCO • DULUTH • WASHINGTON
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SYMONS...

A REGISTERED NORDBERG TRADEMARK

KNOWN THROUGHOUT THE WORLD

Non-Stop Surface Haulage...

Whips the Weather at Climax

Mile-long all-weather conveyor by Stearns-Roger carries 1,500 TPH upgrade

Even in summer the nights at Climax can seem mighty cool. In winter at 11,000 feet or more they may drop past 40° below. To handle 1,500 tons per hour of moly ore over a distance of nearly a mile, all uphill, Stearns-Roger designed and built a conveyor system that operates efficiently in winter as well as in summer.

Inside the pipe-like structure in the photo runs a four-section 42" belt. The entire length is heated by electricity and fully insulated against freezing.

The same experience and imagination can be applied to your next project. Undivided responsibility carries through, on time, for every Stearns-Roger customer—saves money, avoids failures.

Look to
Stearns-Roger
for undivided responsibility
in
ENGINEERING
DESIGN
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SALT LAKE CITY
HOUSTON
EL PASO
STEARNS-ROGER ENGINEERING COMPANY, LTD
CALGARY

MODERNIZATION is the keynote of this special issue dedicated to Climax Molybdenum Co. On following pages special articles, written by Climax management and engineering personnel, describe the vast improvements in mining and milling, and refinement of living conditions made possible by a recently completed $35 million modernization and expansion program at the company's mine.

Modernization, however, is something more than the installation of facilities and the improvement of mining and milling techniques. Modernization begins in the thoughts of men: the development of ideas not only for the creation of machinery but also for parallel improvements in accounting, selling, exploration, and such important necessities as the handling of men.

At its inception, this issue was conceived to deal exclusively with the mine and mill located at Climax in the rugged high country of Colorado. A few short years ago such a treatment would have been entirely adequate. But today the molybdenum mine, while still the major Climax interest, is but one of many branches of the organization. Climax President Arthur H. Bunker will tell you, "I don't know exactly what we'll be in tomorrow. But I'm quite certain that if a worthwhile opportunity comes along, we'll be ready to take advantage of it."

That Arthur Bunker has confidence in his executive team is apparent, since he hand-picked each member. This group is presented to you on page 725. Back of the executive team Mr. Bunker has sought out and appointed a large group of specialists in every field in which the company is interested: molybdenum, uranium, oil, and general exploration, as well as research, sales, process development, accounting, and human relations.

Although energetic and positive in action, Arthur Bunker is no autocrat. "We have no room for 'yes' men in this organization," he will tell you. "We expect every man to speak his mind. We may not agree with what he says but we respect his opinion and want him to voice it." With that philosophy, Climax operates on a "town meeting" form of management with the result that all management employes participate, if not in formulation of policy, certainly in the manner in which the policy is executed.

The visitor to Climax can hardly fail to catch the spirit of enthusiasm and expectancy that permeates all management personnel. When Mr. Bunker assumed the presidency in 1949 Climax was a one-operation, one-interest company. Today its interests and operations spring in all directions . . . and the observer, too, becomes certain that new enterprises lie just around the corner.

Climax was an early entry in the uranium steeplechase. Its mill at Grand Junction, on the Colorado Plateau, began producing in 1951. Today its uranium activities are spread over a number of company interests on the Plateau and scattered from Texas to Alaska. In addition to uranium, Climax also holds thorium properties which may help feed the national appetite for that atomic material, should development measure up to promise.

Petroleum is another field claiming the attention of the new Climax. Already a major waterflood oil producer, the Climax oil dept. is now seeking additional properties of this type as well as increasing its holdings in semiproven royalty lands. In addition to molybdenum, uranium, thorium, and oil, Climax exploration and development groups are conducting searches for industrial raw materials of all kinds throughout North America.

Perhaps an even more exciting exploration is under way in molybdenum itself. Within the lifetime of many actively interested in Climax, molybdenum has sprung from a worthless metal to become one of steel's important ingredients. Within the last decade this element has reached out to find new and important applications in other fields. Modern gasoline is produced with the aid of molybdenum catalysts; an infinite number of chemical processes depend upon a form of molybdenum to speed their reactions; molybdenum pigments are virtually unsurpassed in the paint industry; and the addition of a trace of molybdenum to certain soils (a mere ounce or two per acre) increases crop yields by as much as five times. Use of molybdenum sulphide as a lubricant has increased to several hundred thousand pounds a year for the past few years.

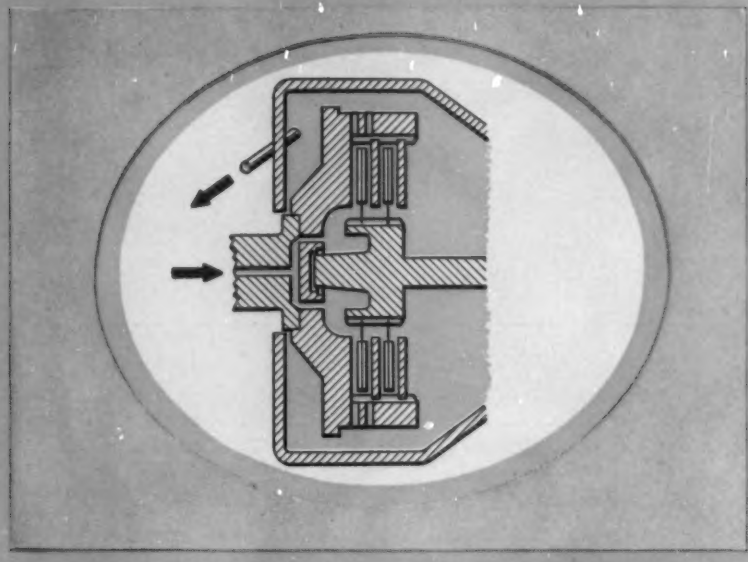
Metallic molybdenum, produced by the Climax arc-cast melting process, promises to open new horizons to jet aviation and the arriving field of high temperature industrial production. And the surface is just being scratched on the possible use of the element in the age-old problem of inhibiting corrosion. Other fields, as yet completely unexplored, can add millions of pounds to the growing demands for molybdenum. New products for the steelmaker and foundryman are now in final stages of development.

The strategic importance of molybdenum was recognized by the Government during World War II and again during the Korean conflict when it was severely controlled. Necessity of future controls might have been obviated by a move on the part of the Government beginning late in 1950 when contracts with a three-fold purpose were given to Climax. Under those contracts the Government assured Climax of a temporary market for the increased capacity of its mining and milling operations; built up a stockpile of molybdenum to be used in possible emergencies of the future; and provided, as a measure of conservation, for the use of some marginal ores that ordinarily would have been lost to future generations. With the vast expansion program at Climax the growing industrial appetite can be satisfied for the foreseeable future.

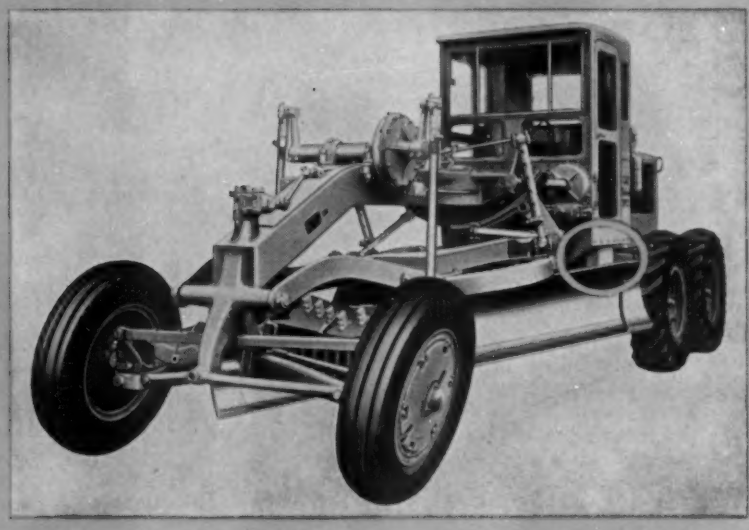
Ed. Note: Because of unavoidable last minute changes, the first four articles in this special issue have been rearranged. This alteration was made after the contents page was printed, therefore the page numbers do not agree.

CATERPILLAR ANNOUNCES ANOTHER "FIRST":

NEW OIL CLUTCH for the NO. 12 MOTOR GRADER



Arrows show path of oil through housing with clutch disengaged. Facings remain cool and bathed in oil, which is carried to outlet at top by flywheel ring gear. The two steel clutch discs and clutch brake are faced with pressure-processed cork, which gives an excellent coefficiency of friction and long wear.



The new oil clutch for the No. 12 Motor Grader gives you the same reliability and improved performance as the thoroughly job-proved oil clutch in Caterpillar track-type Tractors. Rugged and reliable, it uses oil from the engine lubrication system. Here are some of the things the new oil clutch for the CAT* No. 12 can mean to *you:*

LONGER WORK LIFE—In actual on-the-job tests, clutch facings wear less than the thickness of a human hair in one thousand hours' operation! Thick clutch facings mean that work life is extended thousands of hours before discs need be replaced. And constant "oil bath" lubrication reduces wear on all moving parts.

LESS MAINTENANCE—Adjustment every 1500 hours is not unusual, after initial "break in." This is equivalent to nearly nine months without adjustment on road maintenance work! No external lubrication is needed: internal oil system lubricates pilot and throwout bearings.

GREATER EFFICIENCY—The clutch is constantly cooled, never exceeding normal engine oil temperature. This practically eliminates clutch fade, greatly reduces slippage due to overheating, and means that the clutch retains "like new" operation for thousands of hours.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

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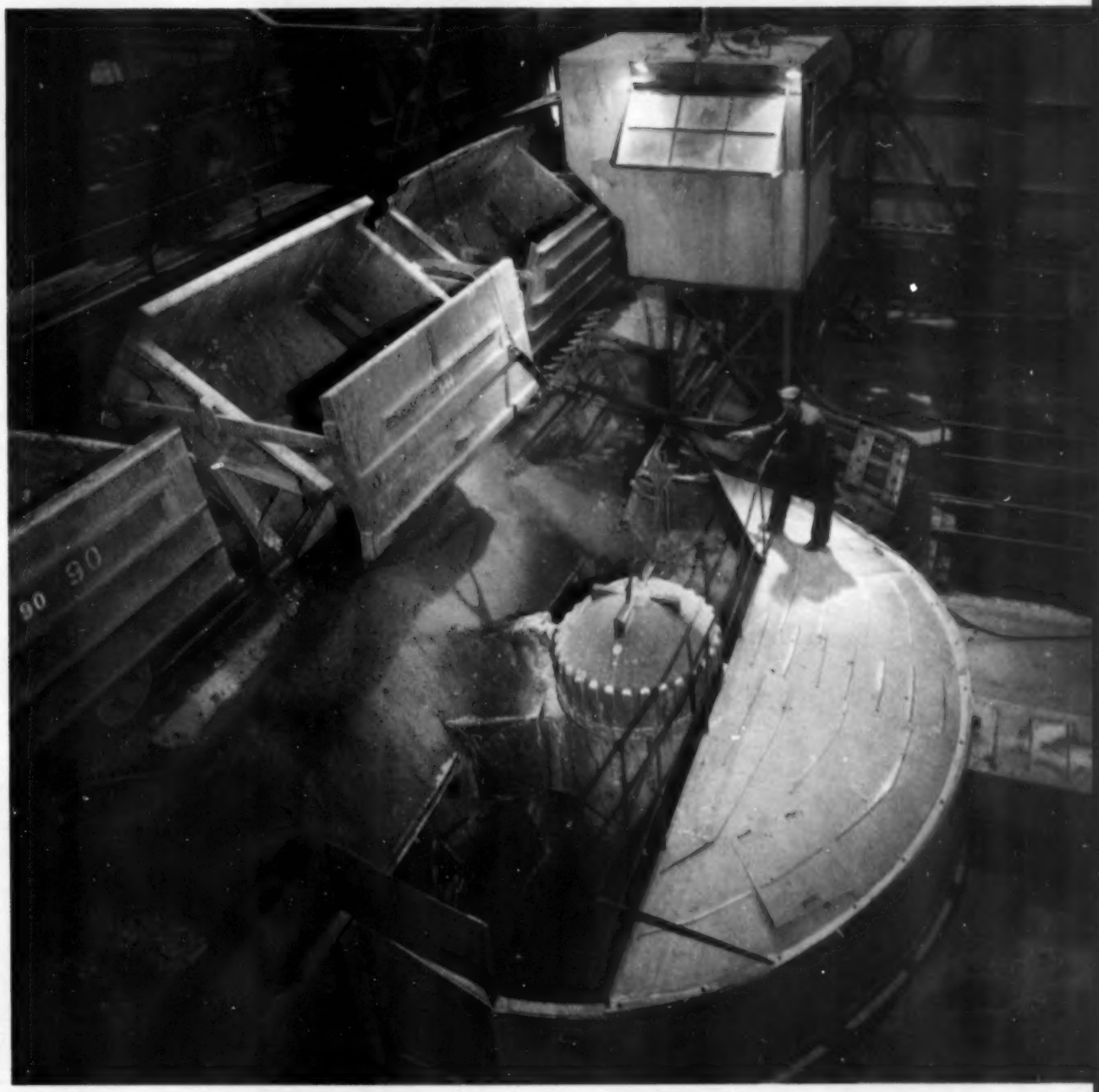
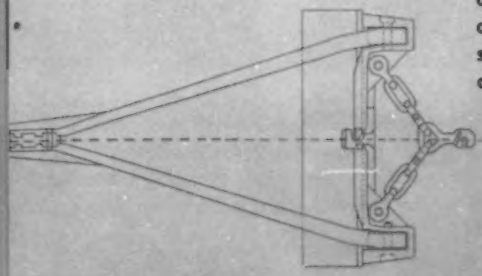
99% OF ALL CAT MOTOR GRADERS ARE STILL IN USE



THE CLIMAX DESIGN

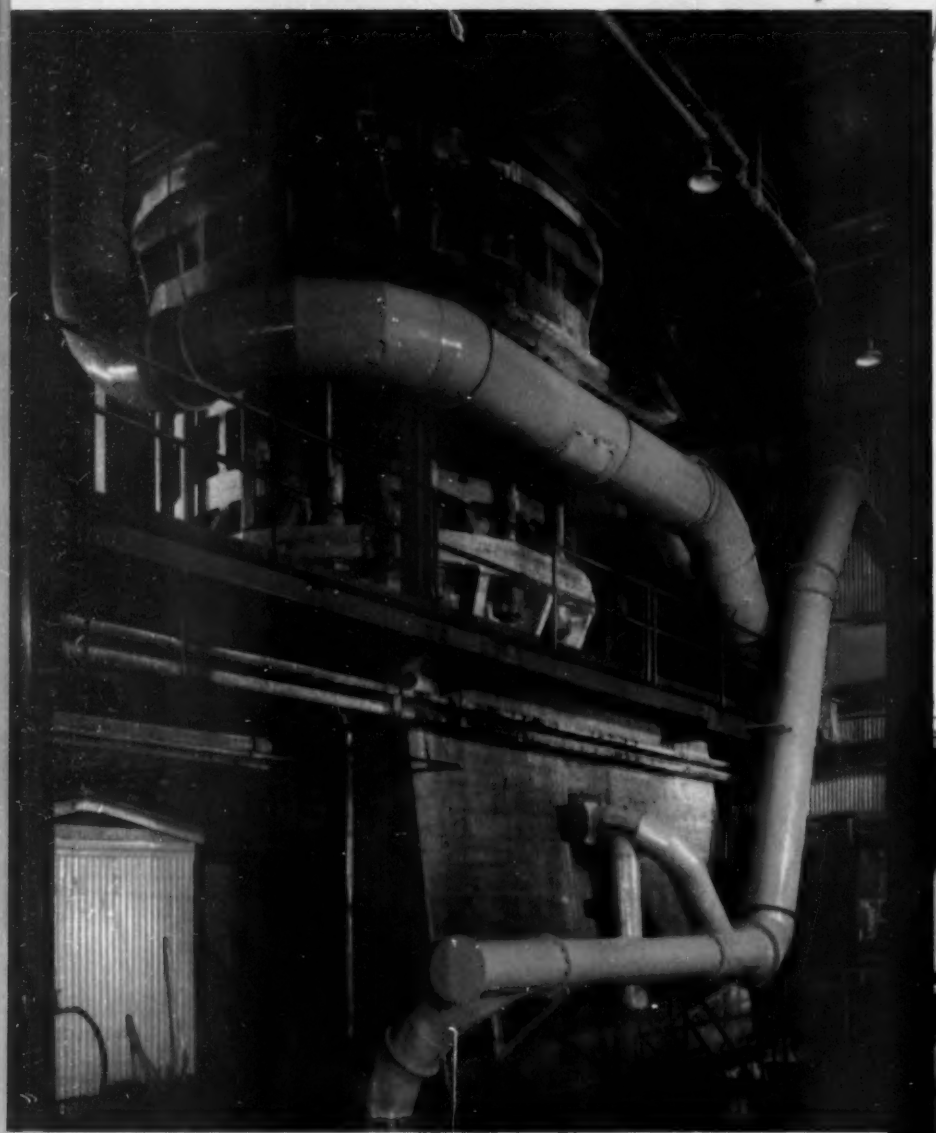
The Climax operation presents the interesting combination of mountain and industrial ruggedness. Color photographers find appealing challenge in a wide variety of scenes that combine the elements in both literal and abstract subjects.

The Climax design is for the human being and his needs. Climax President Arthur Bunker has likened the high mountain operation to a giant, 250 million tons in weight, and 12 thousand feet high. No matter how huge or complicated the plant, the design must assure efficient operation by its human operators. By the same token, living and playing facilities must be designed for fullest satisfaction in use—else the capital investment is not justified. Even the product, molybdenum, finds its application through the ever growing demands of a highly industrialized society of humans. Research in Climax Laboratories, in tune with our technical age, helps guide molybdenum to its maximum use for society.



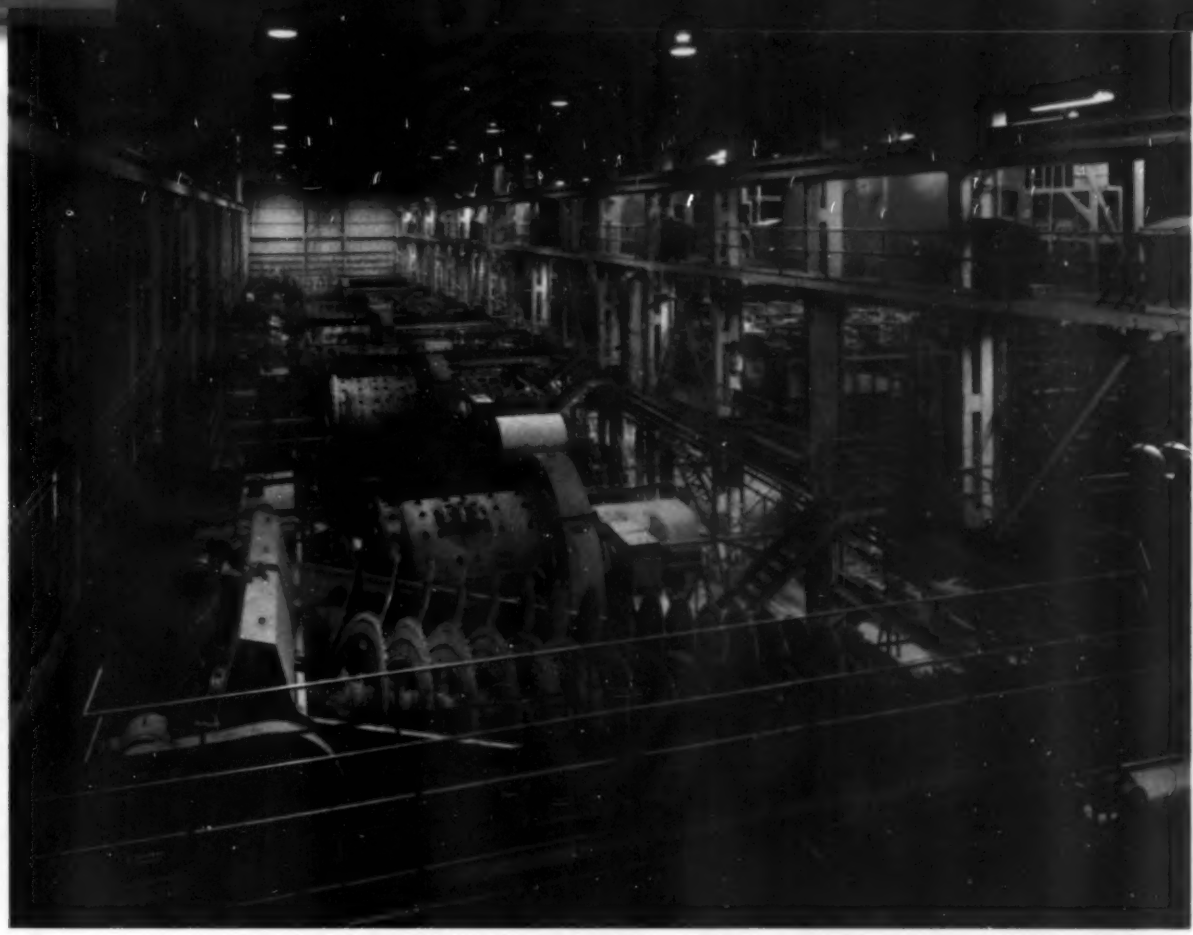
Automation for the underground mining industry is perhaps best exemplified by the caving and slushing systems used at Climax. A highly mechanized system of mining permits an average of 200 tons of ore to be produced by each member of the production crew each shift. Here, a 72" folding scraper, which was developed at Climax, is moving five tons of broken ore to the draw hole from a finger feeding the slusher drift at its far end.

Rugged might releases tiny mineral particles



The 500 ton gyratory primary crusher at Climax stands as a giant crucible to crumble huge boulders received from the Storke Level in the first of a series of operations designed to free tiny particles of molybdenum captured in the rock. This equipment has reserve capacity twice its present demand. Increasing tonnage will pass through its maw as production is shifted to this level in the mine.

Utilizing the affinity of molybdenite for oil, the mineral is floated to the surface of flotation cells. Here the mineral is removed as a foam—to be further purified by a repetition of the process.



After passing through three stages of crushing the ore, the size of pea gravel, is fed to nine foot diameter ball mills where the particle size is further reduced to make possible the separation of the molybdenite mineral from the waste matrix. A spiral classifier separates the coarse material from the fine, re-cycling the former to the mill for further reduction. Fines go to the flotation section.

Concentrates are loaded in freight cars for shipment to the company conversion plant at Langeloth, Pa. A specially built locomotive permanently equipped with a snow plow makes daily trips from Leadville to Climax over the highest standard gage line in the United States.

At Langeloth the concentrate is roasted to produce molybdic oxide from which a wide variety of molybdenum products is produced for the metallurgical, pigment and chemical industries.

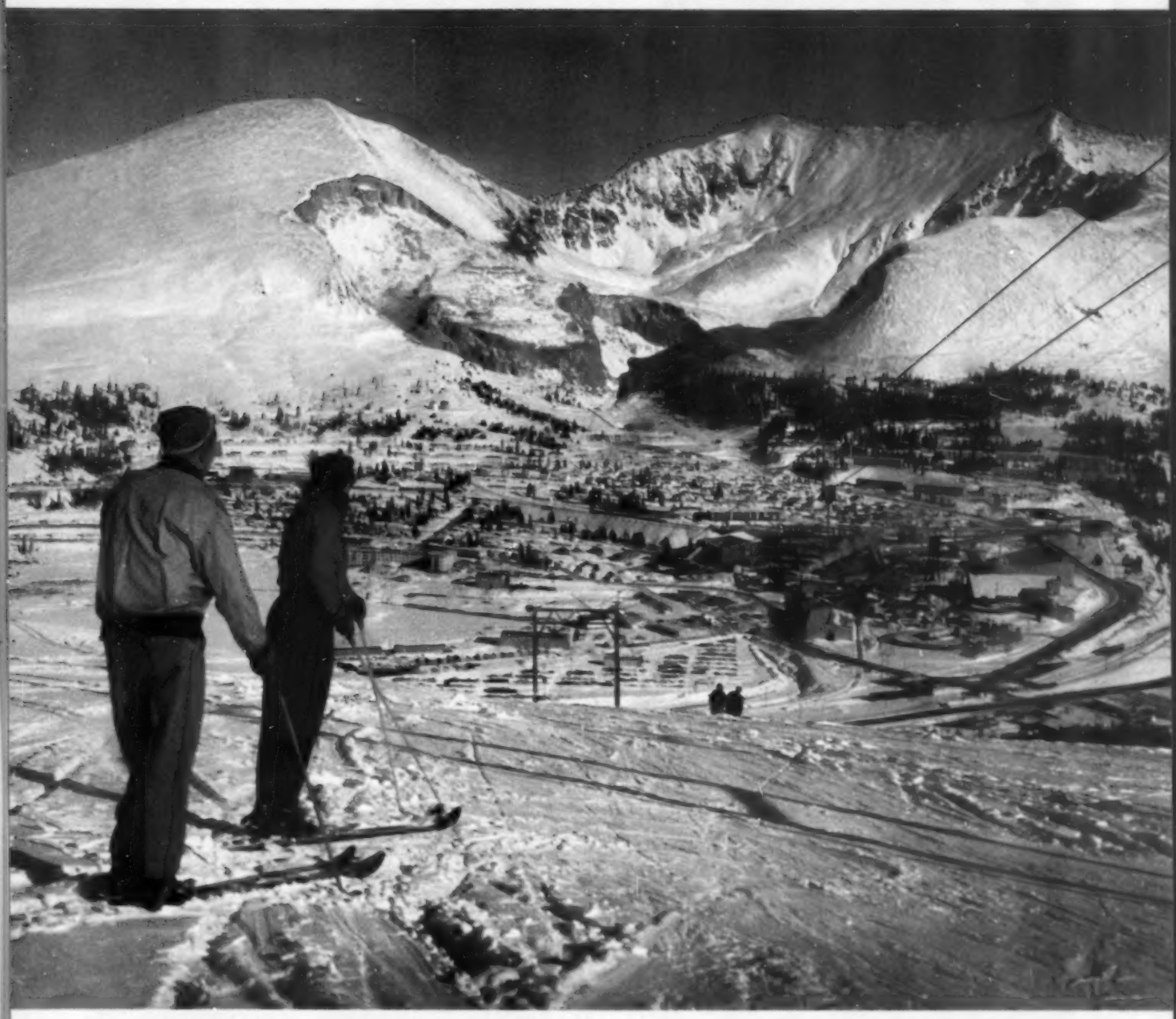
Modern living and recreation are appeals at Climax

The community antenna system brings Denver television programs to Climax families. Here, a member of the mine crew and his wife and child enjoy a TV program in their comfortable Climax home. The system serves 550 homes by direct wire.

Modern shopping center provides a full variety of merchandise for the Climax housewife. Included are modern grocery, furniture and dry goods departments, restaurant, barber and beauty shops, tavern, post office and service station.

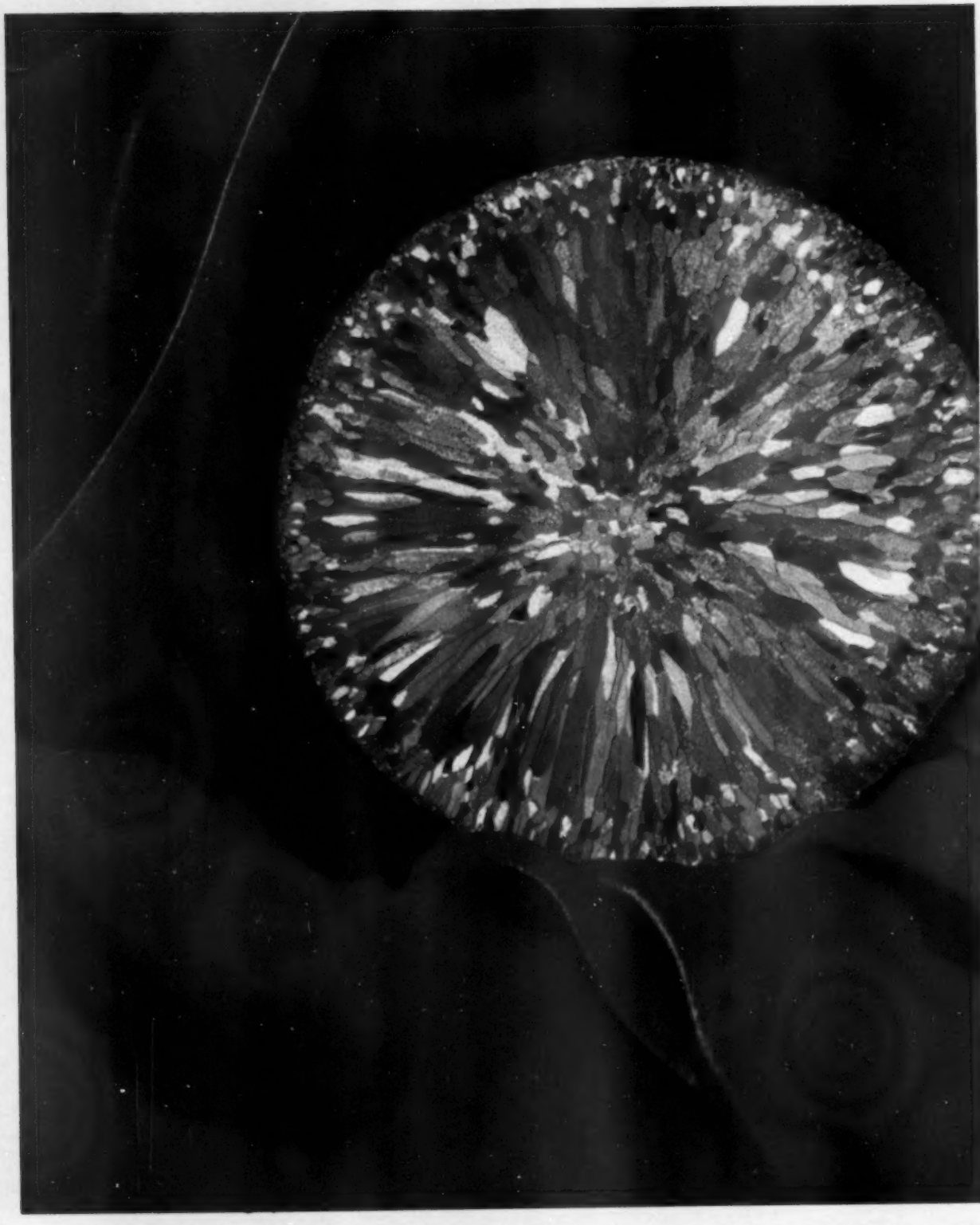
Climax families and visitors frequent the new reception center at the entrance of the property where graphic displays demonstrate the methods by which ore is mined at Climax and molybdenum is used by industry. Movies are shown on the operation.

A beautiful Rocky Mountain setting provides a wide variety of recreational appeal. Fishing, hiking, hunting and photography are popular sports at Climax. Indoor activities include bowling, shooting, basketball, billiards, drama, choral and civic clubs.



Long winters bring heavy snows to the Climax area. Skiing on the Chalk Mountain slope opposite the community is a popular sport. A T-bar lift has been installed by the company and is operated by the Continental Ski Club. A new, enclosed skating rink has recently been completed for the enjoyment of skating and hockey enthusiasts in the community.

(Back Cover) A gigantic enterprise producing three quarters of the free world's supply of molybdenum may be symbolized in its objective by the specimen of an etched cross section of a molybdenum ingot. Molybdenum imparts strength, hardness and resistance to heat in metal alloys. Other products include chemical reagents, pigments, lubricants, soil additives and catalysts. The pure metal finds growing application in electronics and aviation.



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Climax Molybdenum Officials

Arthur H. Bunker
President

Weston G. Thomas
Executive Vice President

Here are the officials of Climax responsible for the planning and operations of the company's properties as well as those of its wholly owned subsidiaries.

Frank Coolbaugh
Vice President—Western Operations and President —Climax Uranium Co.

Reuel E. Warriner
Vice President—Sales

Alvin J. Herzig
Vice President—Research

Lester A. Cowan
Secretary

E. E. Wheeler
Vice President and General Manager—Climax Molybdenum Co. of Pennsylvania

Wallace Macgregor
Treasurer

Climax's western operations are extensive, but the industrial establishment at the molybdenum mine is by far the largest.

Western Operations

are part of

Decentralized Management

Frank Coolbaugh

Director & Vice President—Western Operations

"As one of the largest underground mining operations in the world, techniques have been developed of ore production, handling, and concentration resulting high rates of operating efficiency. Extensive bodies of low grade ore heretofore not commercial have been rendered economically attractive."

THE activities of the various divisions of the Climax Molybdenum Co. are almost as widely separated in scope as the New York offices are physically separated from mining and milling operations on Fremont Pass in the Colorado mountains. Irrespective of barriers imposed by distance or diversity of individual department activity, however, the whole must fit neatly into the common framework of the Climax corporate structure. The overall objective as a producer of important raw materials for industry must be paramount and common to all operations.

This effort is centralized in the executive committee of the company, of which Arthur H. Bunker, as president, and Weston G. Thomas, as executive vice president, are chairman and vice chairman respectively. This group has the authority and responsibility of carrying out the programs established by the board of directors. When programs are formulated for the various operations four essential elements are common in their development: 1) Sound operations require careful planning and enlightened budgetary control. 2) Prudent economy is not based upon a blind policy of "don't spend" but rather upon the objective doctrine of "spend when you need to spend, but spend wisely." 3) Improvement and growth is achieved through continuing inquiry and research concerning tools and procedures, cost considerations, product application, and market conditions. 4) The human resource can be a company's greatest asset, but only as the result of thoughtfully practiced relations in all of its endeavors.

Beyond these basic concepts in the entire Climax organization, a great deal of individuality is practiced by all divisions. The company's geographic and operational diversity justifies a comparatively decentralized executive management organization. Activities centering around mining and concentrating operations, including exploration and process research, are a part of the Western Operations Div. While principal operating facilities of this division are located in Colorado, Utah, and Arizona, exploration is committed to investigation of properties that appear to qualify under concepts of *operational feasibility*, anywhere in the U. S. and Canada.

These concepts of operational feasibility for this company have largely been established as the result of experience at Climax, Colo. As one of the largest underground mining operations in the world, techniques have been developed for ore production, handling, and concentration resulting in high rates of operating efficiency. Extensive bodies of low grade ore heretofore not commercial have been rendered economically attractive. The possibility of this type of new enterprise for Climax is perhaps best illustrated by a comparison of production improvement experienced by the Climax operation with that of American industry as a whole.

Gilbert Burck, in an article in the July 1955 issue of *Fortune* entitled "The American Genius for Productivity," cites the fact that "the U. S. . . . has raised its productivity, as measured by average output per man-hour, by more than six times during the past hundred years." Because of highly mechanized methods and greatly increased rate of production output unit for the miner at Climax in just the past 35 years has risen more than 20 times. Similarly improved efficiencies have been experienced in milling operations.

Since the creation of new mining enterprise through exploration provides a broadened opportu-,

nity for skills now in use in the present operations, it is felt that plans to expand to new ventures provide a mutuality of purpose with employes which, of course, is highly important to all business.

Also included in the exploration objectives is the desire to broaden the base of raw material production in either metallics or nonmetallics of sound commercial appeal. Such diversification in a company program is always beneficial, but the opportunity of being fully selective is a very difficult assignment for any exploration group, particularly in light of the active raw materials search that most major mining companies are pursuing over large portions of the globe.

Of great importance to the functions of both existing operations and the exploration program is the process research dept. with metallurgical and analytical laboratories located at Golden, Colo. Research in this department falls into three main categories: 1) production process improvement on the company's present metallurgical practices, 2) study and development of new improved processes for recoveries of currently produced minerals, and 3) study and development of economic upgrading of ores under consideration by the exploration dept. Work relating to the first two categories is done in close cooperation with operating managements and research departments connected with the Climax and Grand Junction operations.

Another responsibility of the Golden laboratories is to maintain close liaison with any pilot plant tests or metallurgical research projects performed by outside laboratories or research groups. The director of research may also develop the need and outline the scope of the work for these outside projects. Assistance in settling up outside research programs will come through close communication with operating management and technical staff personnel.

Investigative work in many fields related to properties, mining, and processing, which do not logically fall in the normal scope of work of existing departments, may be assigned to one or more of the specialized consultants available to Western Operations. These men, as well as the managers of the exploration and research departments and operating properties and their respective staffs, have made the administrative functions of Western Operations both active and fruitful.

Molybdenum Mining Operations

Edwin Eisenach and Robert Henderson
Assistant General Superintendent and Resident Manager

HIGH on the Continental Divide in the central Colorado Rockies at an elevation of 11,320 ft, Climax is relatively isolated from urban supplies, services, and conveniences. Yet with an average daily mine production well above 28,000 tons of ore, and crushing, milling, byproducts, and tailing disposal installations of corresponding capacities, company requirements are many and varied. It is the continuing purpose of Climax management to equate the means to the objective—to provide the facilities for both human and material satisfaction in the fulfillment of this objective.

At Climax this is not altogether an easy task.

During a typical operating month, 1400 employes work nearly 286,000 man-hr creating a payroll of approximately $750,000. Some 12 million kwhr of electric energy are consumed and one third of a billion gal of water is circulated through the plant. Almost $1 million is spent in equipment, supplies, and services creating employment for more than 1000 additional people in outside companies.

In the community that has been established for employes and their families, modern housing has been provided for 2500 people; hospital, school, church, community protection, recreation, shopping, and post office facilities have been built to accommodate community needs. A community antenna system has brought television entertainment to every Climax home, at no cost to its occupant, except for his own receiving set.

The Climax community and industrial operations spread over an area of 150 acres and are serviced by 8.5 miles of roads—all requiring the unusually costly maintenance imposed by rugged terrain and high altitude weather. Three quarters of the property tax revenues received by Lake County, population 8000, are paid by Climax. Smaller sums are paid to the two counties to the north into which Climax operations also extend.

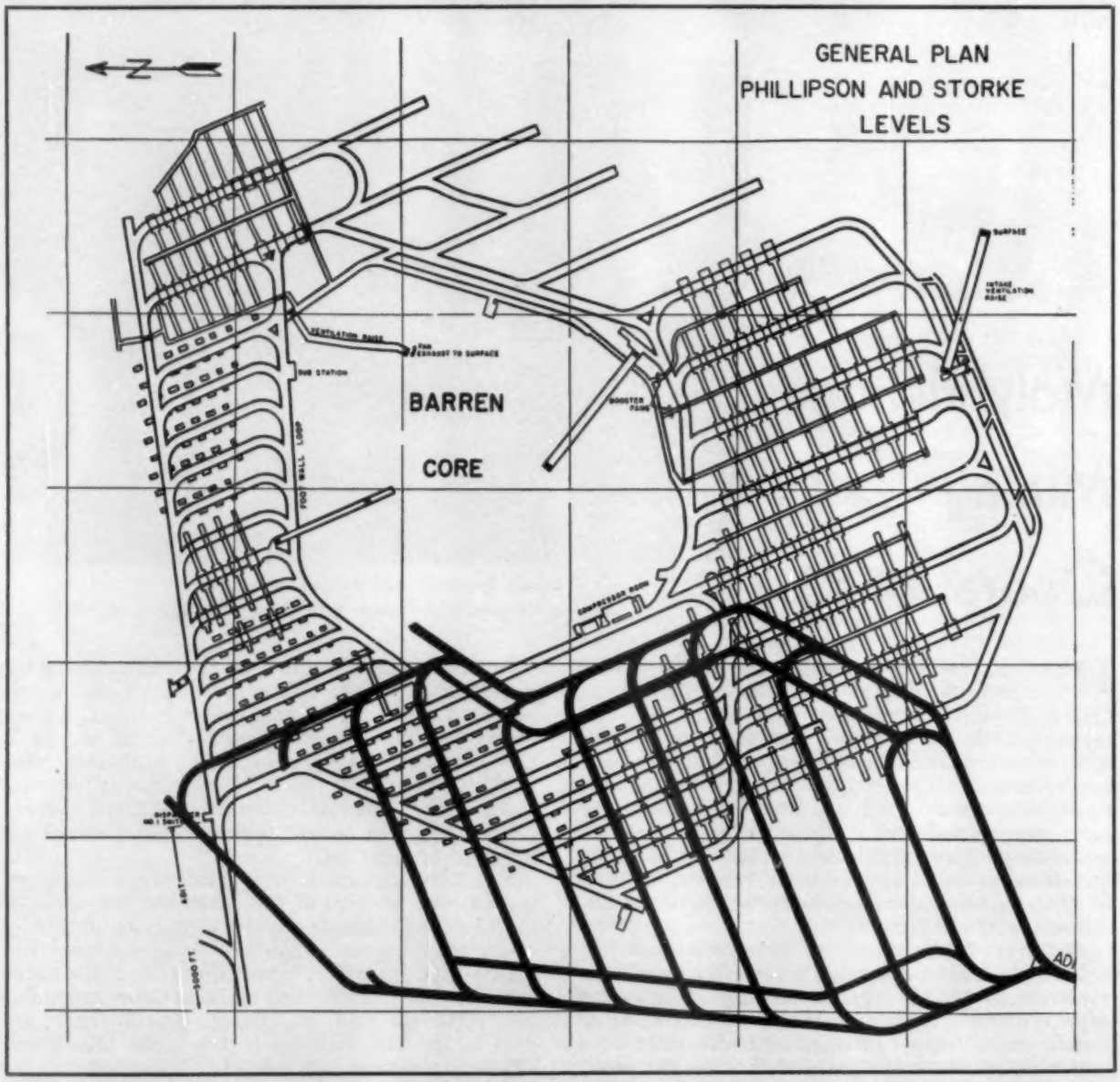
All these facts illustrate the administrative, operational, financial, and—of great importance in any operation of this type—the human problems with

which the company is faced. That progress is being made in solving them is perhaps best measured by the fact that ore production based either upon the number of employes in the muck crew or upon the number of employes in the entire operation compares favorably with corresponding figures in the industry in general. The safety record continues to improve and has for many years ranked high in the industry. Employe turnover has been reduced to about 10 pct of what it was four years ago and is less than the industry average. Markets for Climax's product are constantly growing, and its price, based upon a fixed dollar value, has actually been reduced substantially over the past ten years.

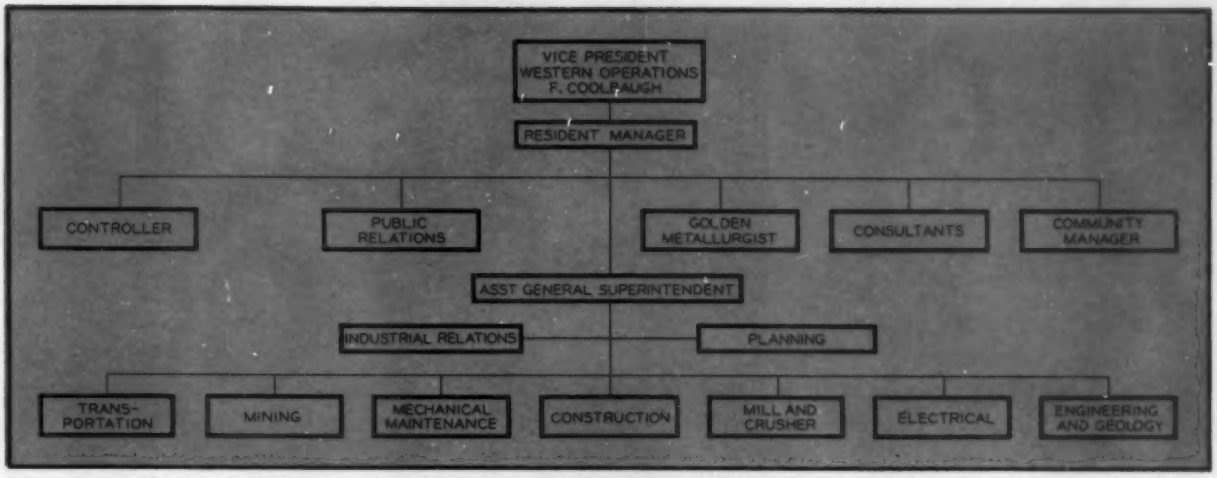
It is therefore seen that the organizational functions required at Climax go beyond those of plants of smaller capacity or of less adverse locations. In addition to the mine, crusher and mill, and engineering departments that are common to most mining operations, there are departments for planning and development, public relations, printing, industrial relations, safety, industrial hygiene, ventilation, training, employment, hospital, mechanical maintenance, electrical engineering and maintenance, transportation, accounting, community management, protection, recreation, budgeting, warehousing, purchasing, metallurgical research, geology, new construction, and general maintenance.

Safe and efficient operations demand the best of teamwork and communications and this can be done only by having the organization properly selected and balanced and the job program carefully planned and followed. Without organization and teamwork the present production could not be attained with this limited number of employes. Good organization leads to good control and morale, encourages initiative, and gives each man an opportunity to do his work.

One man cannot possibly direct the activities of all these functions, and for this reason several top level service and specialized departments performing this work have been established to work most efficiently under the top management team. In this way the burden and responsibility on each man is



General plan of the mine haulage system on the Phillipson and Storke levels give an indication of the magnitude of the operation. Storke level, shown in black, is 300 ft below the Phillipson. Storke adit surfaces are on the eastern slope of the Continental Divide while the upper levels are on the western slope. Scale of drawing is about 500 ft per in.



limited to what can be handled effectively. The combinations of related types of work are shown on the organization chart.

The organization chart itself gives a good picture of the respective responsibilities but it is of little value unless careful planning and organization have set up job descriptions, authority, policies, and channels of communication for each job. The organization chart of the Climax operations is not permanently fixed. Conditions and personnel are changing constantly. Management bases organization on a good understanding of the personnel and human relations problems involved. The work and importance of each department will be described in the articles following.

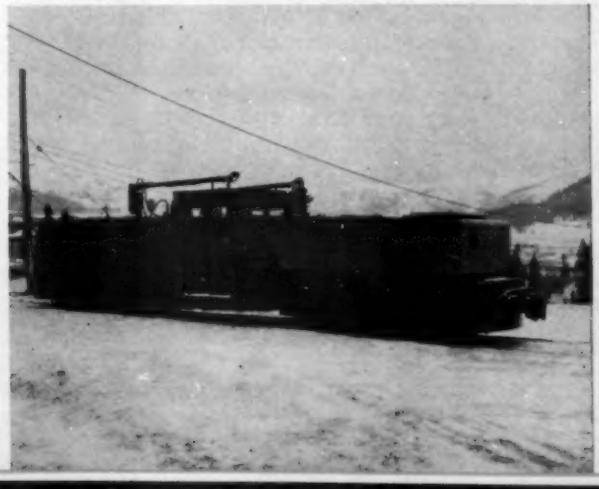
The question may well be asked as to where men are found to fill the positions shown on the chart. The history of the Climax operation does not differ from that of many other mining enterprises. Climax started in a small way with only the basic framework commonly found in mining work. The company has expanded over the years and men have been trained and given background experience to enable them to take on new responsibilities as openings occurred. As much as possible, men are promoted from within the organization. This is especially true within the production field where the men have started in at the bottom and worked up. Occasionally some new work is undertaken and men in the organization are not trained or experienced in the field. In these cases, experienced and qualified men are brought into the organization.

The organization at Climax, Colo., is the largest in the company, and men are being trained not only to take care of future needs of this branch but also for expansion that may result from exploration work now being done. This program will result in increased efficiency as well as a saving in time with the development of new operations. Men experienced at Climax and selected to form the management nucleus for new enterprises should be able to form an effective operating team in the shortest period of time.

Attention should be directed to the importance of research in the organization. Without research, molybdenum might well be of very minor importance today and the market would be correspondingly small. Research and testing groups are to be found at all levels and in all phases of the work. These groups continually check equipment, supplies, and methods to find safer and more efficient ways of getting the many jobs accomplished.

The overall importance of good teamwork and organization can be understood better with the full realization that the amount of molybdenum and by-products per ton is small and the value per ton low. Good communications and organization at Climax, properly coordinated with the other segments of the company, make it possible to operate economically.

As the metal content of the ores mined in the U. S. decreases, the tonnage per manhour must be increased enough to maintain some form of balance in the cost of production of the metal. Expansion at Climax has introduced new equipment and improved methods capable of handling increased tonnage requirements.



Engineering and Geology

M. S. Walker and R. H. Taylor

Chief Engineer and Assistant

FROM 1917 to 1926 mining at the Climax Molybdenum Co. property was confined to the Leal and White levels at elevations of 12,145 and 11,935 ft respectively and to surface outcrops above the Leal level. At present the production is coming from the Phillipson and Storke levels at elevations of 11,465 and 11,168 ft.

Until 1926 when B. S. Butler recognized the relationship existing between the orebody and a central core of fine-grained hydrothermal quartz, the orebody was believed to be tabular in form. The orebody lies within the pre-Cambrian granites and schists and another rock type designated as the Climax porphyry and surrounds a highly silicious core, the mineable portion of which varies in thickness from 250 to 400 ft.

West of the ore deposit the Mosquito fault, which separates the Paleozoic formations from the pre-Cambrian, strikes N 10° E and dips 72° W with a displacement of 2000 to 5000 ft. On the eastern flank of the orebody the strong fracture zone, the Major fault, strikes N 23° W and dips 42° E. Another fracture zone known as the west shear zone occurs in the southwesterly part of the orebody. This zone strikes N 50° W to N 80° W and dips approximately 25° NE. The Mosquito fault limits any mining to the west and the Major fault approximately limits the orebody on the east. The west shear zone has increased the mining costs where it has been penetrated.

Mineralization, considered to be early Tertiary, is characterized by fracture filling of molybdenite-quartz veinlets. Most of the veinlets are less than ¼ in. wide. Molybdenite (MoS_2) is the primary economic mineral, and secondary minerals recovered are hubnerite, pyrite, and cassiterite. Molybdite produced by oxidation of molybdenite near the surface and along fracture planes is not recovered in the milling operation. Fluorite and topaz also occur but not in economic quantities.

Slusher Drift Mining Proves Economical

The Phillipson and Storke levels are laid out with loading drifts on 200-ft centers and between each loading drift there is a ventilation drift that exhausts the air from the slusher drifts. Although the older areas were mined by gravity with a grizzly system, all mining at present is with slusher drifts.

The mineable limits of the orebody are determined by diamond drilling. The stoping limit, at present set by the 0.4 pct MoS_2 boundaries, probably will be reduced in the future as mining and milling advancements are made. The main footwall and hangingwall drifts have been driven outside the 0.4 pct limit of the orebody and are connected with loading drifts on 200-ft centers. Slusher drifts are usually laid out on 68-ft centers and normally have three pairs of fingers per drift; however, the number of fingers in a drift may vary from one in the case of a stub-slusher drift serving an ore pass to ten in special cases.

Exact Engineering Is Important Feature at Climax

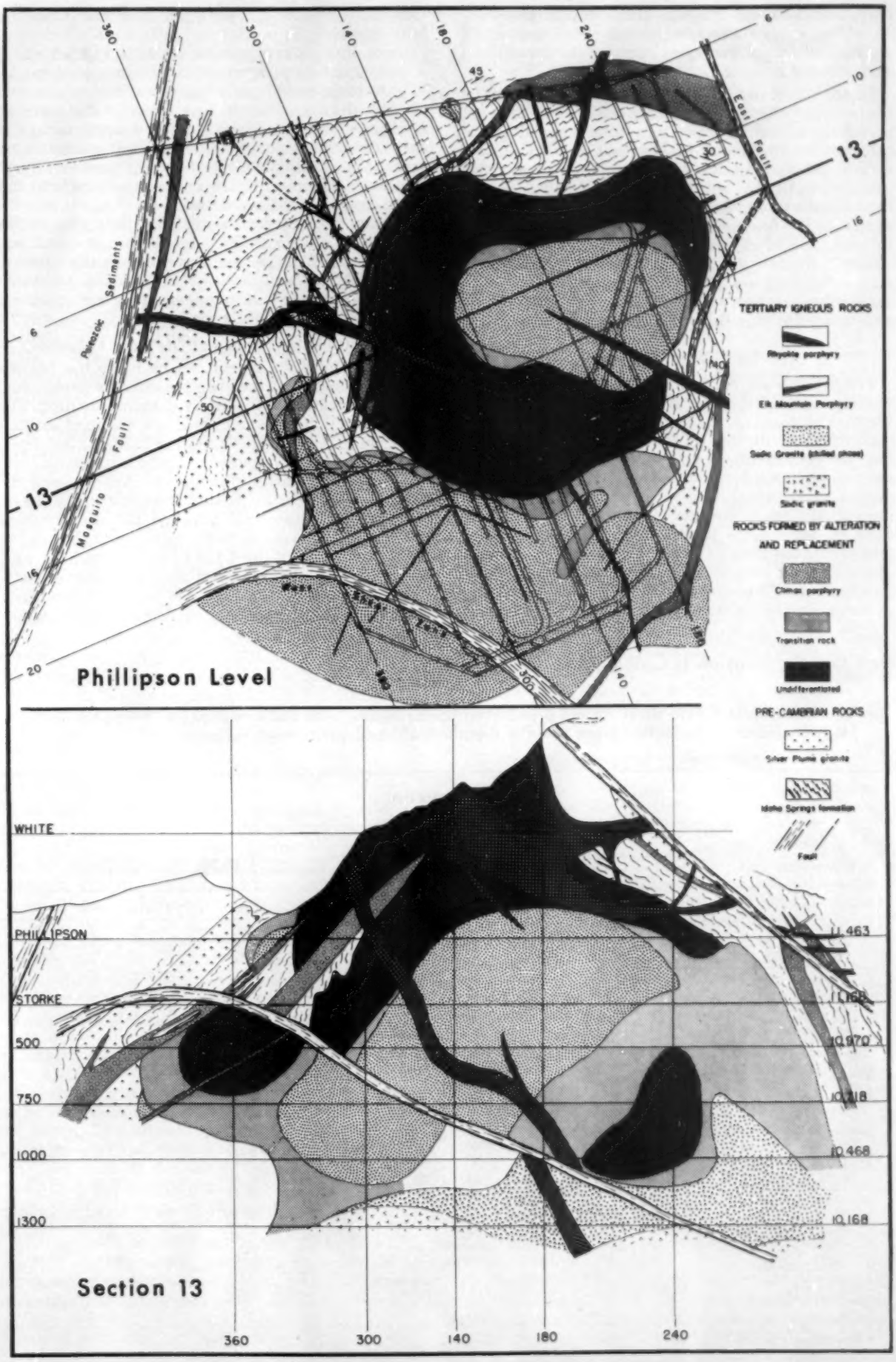
Climax is the second largest underground mining operation in the world, the production at the present time being in excess of 28,000 tpd. To maintain the mine in condition to produce at such a rate it is obvious that development work must proceed at a rate at least equal to the tonnage withdrawn.

The department is responsible for planning and preparation of the development and production schedules for a period of five years in advance and for compilation of statistics connected therewith. These schedules are based on the estimated production needs for the succeeding five-year period.

Design work in connection with both surface and underground installation is generally carried out in the engineering dept. In times of very rapid expansion, outside help is called upon.

The department is also responsible for the execution of mine layouts, ore reserve calculations, ex-

Plan and section of Climax mine orebody and surrounding rock types. Scale about 1 in. equals 600 ft. *(For detailed geology, see* MINING ENGINEERING, *January, 1955.)*


Phillipson Level
Section 13
TERTIARY IGNEOUS ROCKS
Rhyolite porphyry
Elk Mountain Porphyry
Sadie Granite (chilled phase)
Sadie granite
ROCKS FORMED BY ALTERATION AND REPLACEMENT
Climax porphyry
Transition rock
Undifferentiated
PRE-CAMBRIAN ROCKS
Silver Plume granite
Idaho Springs formation
Fault
Paleozoic Sediments
Mosquito Fault
East Fault
WHITE
PHILLIPSON
STORKE
500
750
1000
1300
360
300
140
180
240
13
10,463
10,168
10,970
10,318
10,468
10,168

ploratory diamond drilling, canal design and construction, water rights, claims and claim assessment work, ventilation, surveying, both underground and surface, and sampling.

In analyzing particular blocks of ore to determine the amount of work necessary each year to meet preparation requirements, ore tonnage and grade calculations are made. Against each block having a certain calculated tonnage of ore, there are definite items of work that must be accomplished from the initial haulage drifting until the block is caved and available for draw. Phases of mine work required to bring the block into production such as loading cutouts, slusher drifting, stoping, cutoffs, slusher drift concreting, ventilation drifting, ventilation connections, ore passes, service raises, ventilation raises, and equipment for slusher drifts are itemized.

Unit Costs Are Used

From previous experience records a unit price has been established to accomplish each phase of work. The total units of work of each phase to be performed, multiplied by the unit cost, gives a total cost for each item. The summation of the costs of individual items determines an overall cost to prepare a given area. The ratio of the cost of each individual item to the cost is determined. From this ratio or percentage are calculated the equivalent tons that each item of work will prepare. As each phase of work progresses, each unit prepares a certain tonnage. Therefore, the amount of preparation work required each year can be determined to maintain the ratio of 1:1 between tons prepared and tons drawn.

Even though preparation work is carried on at a rate equal to production, it is sometimes necessary to maintain a much higher ratio of tons caved to tons drawn. This is true because the tonnage available for draw is affected by numerous factors such as draw control, summer and winter draw areas, and development and repair work. A large amount of tonnage may be broken and prepared but is not immediately available.

As the preparation work progresses, the office section maintains statistical records of costs and performance. This section also prepares the monthly and yearly reports into which are incorporated summaries of ore reserves per block and progress reports of preparation work by blocks.

Careful Determination of Ore Zone Required

Before any mine layout can be made the boundaries and heights of the ore zone must be determined from information gathered by diamond drilling. The geology section is in charge of the diamond drilling program. To date approximately 255,000 ft of drilling have been completed. There are no definite structural boundaries to define the orebody, and the zone of mineable ore is thus determined by assay. However, the transition between the silicious core and the 0.4 pct zone is much more rapid than is the transition between the 0.4 pct ore zone and the —0.4 pct zone on the hangingwall portion of the orebody. The resident geologist and his assistant determine the location and sequence of new drilling, log the

How Ore Preparation Is Calculated

This is a standard data sheet for ore preparation computations, with the exception of "Prepared This Month" column. Information given is for a hypothetical block under development.

Ore Preparation

Block "X" Sub-level
Tons 1,234,900 — **MO Pounds (thousands) 6,613** — **Estimated Preparation cost per ton $0.496**
Grade 0.446% MoS_2 — **MO Pounds Recoverable per ton 5.35** — **Actual Preparation cost per ton $0.377**

Type of Work	Original Estimate					Completed to Date				
	Quantity	Cost		Equivalent Tons		Units	Quantity	Cost		Pct of Total Units	Equivalent Tons
		Unit	Total	Unit	Total			Unit	Total		
Preliminary Preparation:											
Footwall Work:											
Loading Cutouts											
Excavation*	3	4,500	13,500	9077	27,232	No.	1.05	979	$1,028	35%	9,531
Equipment*	3	4,500	13,500	9077	27,232				437		
Slusher Drifts											
Excavation, ft	447	65.00	29,055	131	58,609	ft	213	42.15	8,977	48%	28,132
Concrete, cu yd	3380	40.00	135,200	81	272,721						
Ventilation											
Raising, ft	250	28.00	7,000	56	14,120	ft	310	12.72	3,942	100%	14,120
Service Entries, ft	407	52.50	21,368	106	43,103	ft	367	53.11	19,490	90%	38,793
Ore Passes, ft	153	50.00	7,650	101	15,431	ft	183	23.63	4,324	100%	15,431
Sill Work											
Loading Cutouts											
Excavation*	3	3,500	10,500	7060	21,180	No.	3.00	2,197	6,591	100%	21,180
Equipment*	3	5,000	15,000	10086	30,257	No.	1.85	4,191	7,754	62%	18,759
Slusher Drifts											
Excavation, ft	175	60.00	10,500	121	21,180	ft	218	41.80	9,113	100%	21,180
Concrete, cu yd	1435	40.00	57,400	81	115,785	cu yd	1006	29.47	29,651	70%	81,050
Ventilation											
Raising, ft	25	28.00	700	56	1,412	ft	25	24.16	604	100%	1,412
Connections, ft	65	35.00	2,275	71	4,589	ft	93	8.74	813	100%	4,589
Service Raise Stations, cu ft	7600	0.65	4,940	1.31	9,965	cu ft	10304	.55	5,673	100%	9,965
Equipment*	1	5,000	5,000	10086	10,086						
Service Raises, ft	112	100	11,200	202	22,592	ft	87	101	8,822	90%	20,333
TOTAL PRELIMINARY PREPARATION			$344,788		695,494				$107,219		284,475
STOPING, SQ FT	43,680	6.12	267,408	12.3	539,406						
TOTAL PREPARATION			$612,196		1,234,900				$107,219		284,475

* Number of units.

holes, prepare drill logs on the holes, and prepare ore zone maps. Drilling is normally spaced on 200-ft centers initially, with later drilling on 100-ft centers.

With the aid of ore zone sections the chief of party can lay out a mining plan for a particular block. Due to the economics of the mining operation, the minimum height of back required to mine an area profitably is approximately 125 ft above the stoping level and at a grade of +0.4 pct zone plus 15 pct of the ore column for dilution. From past experience it has been determined that the average grade for dilution is 0.220 pct. In footwall areas where the ore cannot be recovered from the Phillipson level without first drawing large amounts of −0.4 pct ore, sublevels have been established along the footwall boundary of the orebody. A boundary cutoff is made along the footwall by driving shrinkage cutoffs between stopes.

At the present time sublevel mining on the footwall is being carried out on seven levels between 11,940 and 11,540 ft as well as on the Phillipson level (11,463) and the Storke level (11,168).

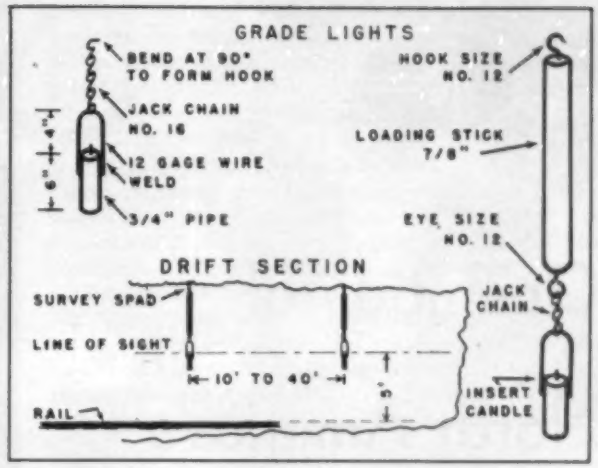
Each engineering crew is responsible for the work in a definite area or block on the Phillipson level. One crew is charged with the entire engineering work on the Storke level. During the driving of haulage or loading drifts the survey crew is responsible for center lines and grades. After a loading drift is driven a loop survey is made and tied into a previous loop survey and balanced. Then future work is started from a previous loop survey.

Center line points are often lost during the life of a loading drift and may need to be replaced several times. After a loop survey is completed in a new drift, permanent concrete monuments are placed at the points of tangency to establish a base line for re-establishing points in the drift. The permanent monuments consists of a piece of steel embedded in concrete, the top of the steel being placed below the bottom of the ties.

Slusher drifts are normally 112 ft long from the center of the drawhole. Slusher drift, loading cutout, and finger raises are lined with concrete, which is not for support, but is used to prevent raveling of the rock in the finger raises and slusher drift caused by secondary blasting and gouging action of the slusher scraper. Slusher drifts are driven on a +3.5 pct grade to provide drainage and to favor the load during slushing.

The center line location of each slusher drift is marked by the engineering crew prior to mining the loading cutout and hoist cutout. Center line and grade lines are maintained to drive the slusher drifts. A final check is made by the engineering crew to determine that the slusher drift has been driven to size before it is turned over to the concrete crew for concreting. No transit surveys are carried beyond this point with the exception of running boundary stope surveys and surveys to drive cutoff raises. The alignment of undercutting in the stopes is done by the shifters who are provided with Brunton transits. If regular survey crews were responsible for the stope work it would require several more stope engineers to keep pace with the development.

Practically all the development mining is done on contract. The contract engineer, who represents the company, is responsible for contract rates, preparation of contracts, and computation of contract earnings. Measurement of contract advances and computation of earnings per contract are done by the underground survey crew for the particular block.



Grade lights have proved to be a satisfactory method for carrying a drift or raise ahead of the last survey point without benefit of a transit to mark centerline or grade. In most instances the miners mark the face before drilling.

Control of Draw Vital to Successful Caving

By area draw every point in an area is drawn at the same time. Draw control is the regulation at each draw point. A record is maintained of the percentage of the ore column withdrawn over each draw point in order to keep it as near the prescribed percentage as possible.

Area draw was difficult or impossible to obtain with the old double-ended slusher drifts since only one side of the drift could be pulled at a time. The present system uses single-ended slusher drifts. With single-ended drifts the draw point spacing is reduced and area draw can be accomplished. Draw control is aggrevated by the muck crews pulling too heavily from the fingers nearest to the draw hole.

Sampling and Surface Work

Samples are taken from the slusher drifts being pulled each day. One sampler is assigned to each of three shifts on the Phillipson level and one to the day shift on the Storke level. Satisfactory sampling is obtained because the daily tonnage comes from relatively few draw points, and there is an unusually uniform distribution of mineralization. Results from the mine sampling agree quite closely with the mill heads and a correction factor is applied to the mine samples to make them conform to the mill heads.

Surface engineering work must be done during the few summer months, although some necessary planning work is accomplished during the winter. An extensive triangulation network has been established which embraces an area in excess of 10 sq mi. When it is necessary to run a survey in an isolated area, the survey can be started from one of the triangulation stations whose coordinates have been established, saving time and decreasing the possibility of error in running a long traverse.

Such work as extension of the canal system, water rights, and claims assessment work is the responsibility of the engineering dept. Extra personnel are added to the crews during the summer months to complete the required outside work during the short summer work period.

Engineering work at Climax is similar to that at any other mining property. However, due to the climatic and other conditions peculiar to this operation, procedures have been devised to best suit particular local needs.

Operation of North America's Largest Underground Mine Is Complex

Compressed air for all underground operations is supplied by the three units housed in this structure. Supply lines for both the Phillipson and Storke levels are carried down the main intake ventilation raise.

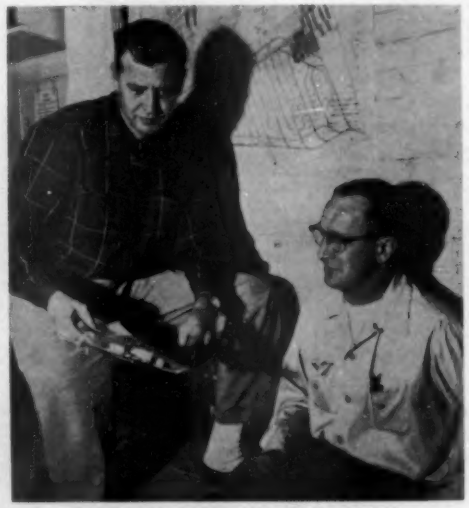
GENERAL mining practices at Climax are much the same as those for caving systems used in mines throughout the country, but the difference in cavability of the ore at Climax introduces many variations. Throughout the ore zone all pre-ore rocks are intensely fractured. It is difficult to find a cube of rock 2 in. on edge that does not contain at least one fracture. By contrast, joint planes in the highly siliceous waste on the footwall are spaced from 10 to 40 ft apart. From tabulation of the jointing in diamond drill cores it was concluded that there is a definite correlation between the amount of jointing and the ease with which rock caves.

Ore jointing or fracturing at Climax varies a great deal between the Phillipson and Storke levels. On the Phillipson level the rock surrounding the ore is generally quite strong and requires a minimum of ground support during mining operations. Rock on the Storke level is more fractured and requires more support during the mining cycle, but also caves more readily. Production figures for 1954 show this contrast—the Phillipson level output was 144 tons per production manshift while the Storke level output was 256 tons per production manshift. Even though the ore zone is well fractured it is still considered to be medium strong rock as evidenced by the fact that weight and point-pressure problems have not caused too much concern where a reasonable sequence of mining operations has been followed. Further, stopes have a tendency to arch after being undercut.

Boundary Cutoffs Key to Successful Caving

The most notable example of arching is the 940 footwall arch which covered an area of 110,000 sq ft before caving action started and is still only partially caved. More cutoff mining will have to be done to insure complete failure of this arch. The arching tendency of the Climax orebody is a function of cavability and is responsible for overall mining procedures.

In the stoping operation, a system of retreat blasting of pillars is used to insure inspection of rows of pillars previously blasted. Remaining stubs of pillars must be removed to prevent development of point pressures and to open the maximum area of undercut so that caving action can start immediately. Advance of the panel cave must be done in a



John M. Petty and William Distler
Mine Superintendent and Assistant Superintendent

regular manner. Up to the end of the war this had not been the practice. This resulted in the formation of many arches, with poor recovery of ore.

The layouts for boundary stopes now call for a smooth boundary and regular cutoff mining. Cavability of the rock is one of the major factors considered in determining the height of cutoff, which varies from 50 to 150 ft, and the vertical angle of the cutoff plane is usually 75° or more. Flatter angles give very poor results, but have been used where it is desirable to attempt to recover small blocks with a low height of ore column. In this case the rock must have a strong tendency to arch in order to insure a reasonable recovery of the ore. Clean pillar mining, smooth boundaries, and ample cutoff stoping are necessary for good ore recovery.

Caving Control

When mining is completed and drawing of the ore begins, area draw and draw control are extremely important. The care with which the first 30 pct of the ore is drawn has a major influence on the overall recovery from the stope.

Area draw indicates that every drawpoint in a given area is being drawn as nearly as possible on a day-to-day basis. This results in a general settling of the ore mass and if a dilution zone overlays the ore this zone is lowered on top of the ore as a unit. Boundary shearing is also a result of good draw and must be accomplished as soon as possible after draw is started to obtain the maximum ore recovery.

Boundary shearing has been noticed at the surface over a group of stopes on area draw from which about 2 pct of the total rock column had been extracted. This is not the general rule. However, boundary shearing should be accomplished within the first 15 to 30 pct of draw depending on the distance from the stoping level to the surface.

Draw control refers to the systematic withdrawal of the ore on a volume basis which is measured on the percent of the ore column. It has been established that a 45° line of retreat to solid ore gives the best control over dilution. This means that a draw limit of 10 pct of the total ore column is set on the drawholes against the unbroken ore. Going away from the unbroken rock, the allowable draw increases 10 pct per row of drawpoints. When an increase in draw is required the limits can be relaxed to a 15 pct differential for those drawpoints from which the extraction is greater than 50 pct.

Area draw and draw control require that the mining layout be so arranged that the broken rock can be disturbed under every square foot of the ore column. With coarse rock a large drawpoint spacing will give satisfactory recovery and with small rock a closer spacing is required. If the drawpoint spacing is too great relative to the size of the rock, the zone of disturbance will not cover the stoping area. Pillars of solid rock supported by broken rock will remain and can allow funnels to form which would dilute the ore with waste. The proper drawpoint spacing at Climax is determined to be about 33 ft in all directions.

Four Divisions in Mine Dept.

The mine dept. has 700 men employed in four major divisions. It is the job of the 180 men on the development and preparation crews to drive the haulage and fringe drifts and ventilation drifts and raises; prepare the slusher drifts, fingers and cutouts for concrete; and undercut the area after the concrete has been placed. Development and preparation are the only types of work where incentive or bonus contract payment is used.

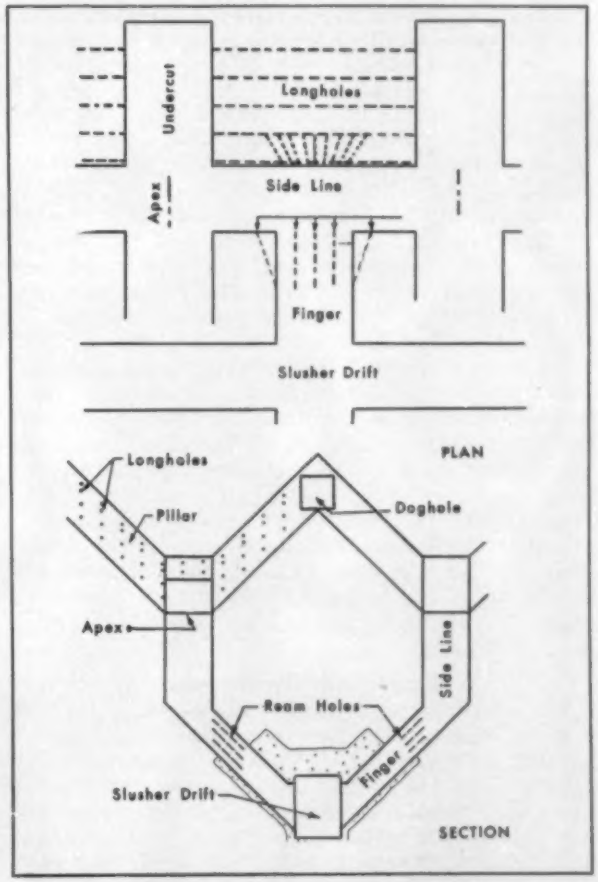
The forming and pouring crews for concrete placement have about 145 men. In 1954 these crews placed 44,093 cu yd of concrete on the Phillipson level and 14,703 cu yd on the Storke level.

The production crews consist of 110 men on the Phillipson level and 35 on the Storke level. The mine is operated three shifts a day on the Phillipson level and two shifts a day on the Storke level, producing an average of 27,000 tpd. These crews perform secondary blasting, loading, hauling, dispatching of trains, and car cleaning.

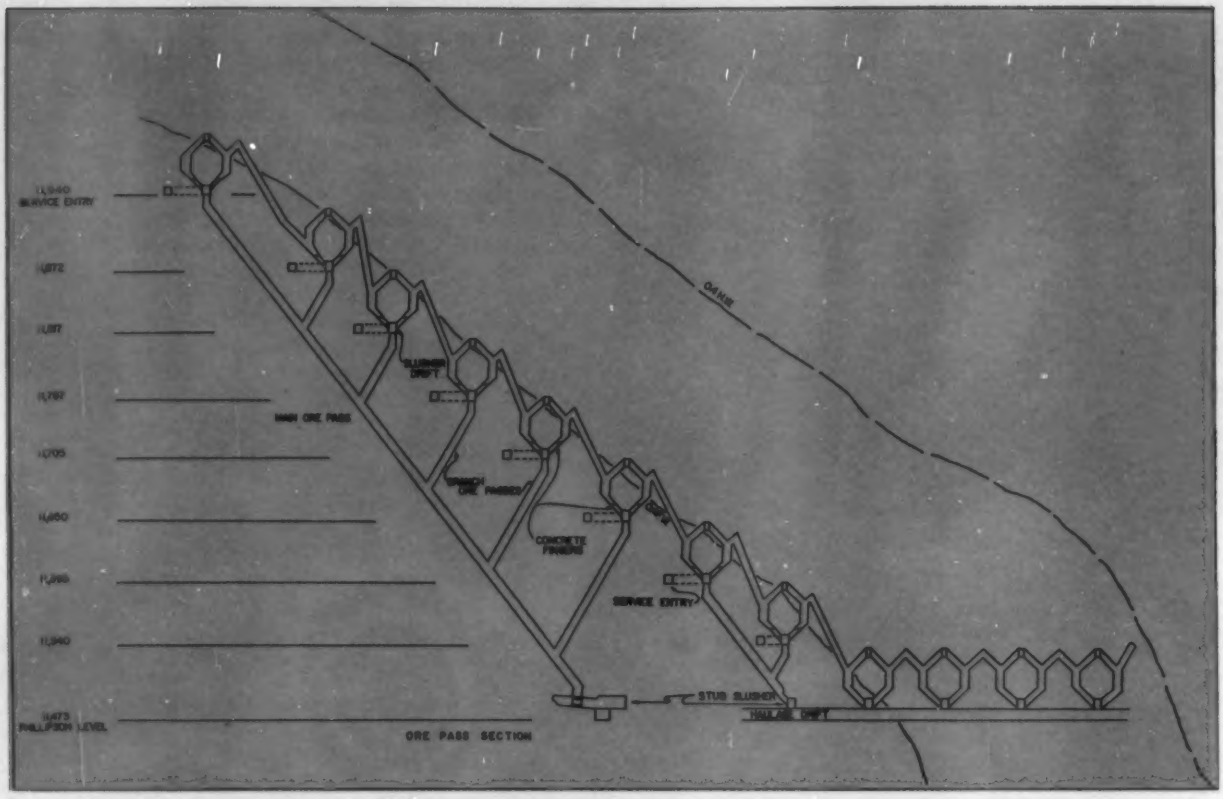
The repair, maintenance, and mechanical crews require about 170 men for repair work on timber and concrete and moving slusher hoists. Although there are a large number of production hoists available, it is necessary to move them from one location to another to obtain good area draw control on both levels and provide for seasonal operation on the Phillipson level.

Underground Development

Main and loading haulage drifts at Climax are driven 15 ft wide x 13 ft high where timber is



Plan and section of stoping methods used at Climax to undercut for caving. Fingers, side lines, and undercuts are all driven on a 45° angle, thereby eliminating any need for mucking machinery. Dotted lines indicate longholes for blasting remaining pillars. Four blastholes in a vertical row are spaced on 3-ft centers.



Section through No. 2 South Footwall development showing relative positions of slusher and entry drifts, ore pass system, and stub slushers for transferring rock to haulage cars. Inclined service raises supply the area. The zone under development extends from 13 Section around to 180 Section. (See page 731.) This footwall program will produce more than 10 million tons of ore.

used and 13x11 ft in unsupported areas. A two-machine hydraulic jumbo mounting 3½-in. drifters is the drilling apparatus for advancing the large headings. The drill steel used for these drills is interesting, in that it is made up of a 1⅛-in. round shank rod coupled to a 1-in. round drill rod. Variation in heat treatment as well as composition gives longer life to the two pieces. The 9-ft rounds are fired electrically with either millisecond delay or regular blasting caps.

Large air-operated rocker-type loaders dump directly into the 200-cu ft Granby haulage cars. Where timbering is required, 12x12-in. posts and caps, with 3x12-in. lagging, all Oregon fir, are used. Set spacing on 5 to 10-ft centers depends on the rock conditions, but spacing for loading drifts is altered to fit the slusher drift drawhole spacing.

Smaller ventilation drifts and entry drifts on the haulage levels or the footwall development are driven with similar equipment, but on a smaller scale. Timbering is reduced to 8x8-in. posts and 2x12-in. lagging.

Slusher Drift Development

The sequence of mining a slusher drift begins with pouring concrete legs from the bottom of the haulage to the sill of the slusher drift. Then the hopper cutout is driven to specified height and width to provide space for a crawler beam and service platform, ventilation lean-to, and manway landing. The manway and a stand for the car-spotter are poured with the legs of the cutout.

One 9-ft round is driven in both directions along the slusher drift center line and mined to size for concreting the entire drawhole cutout. Previous to concreting the cutout, a hopper is installed on the concrete legs.

The cutout section is designed to be 7 ft from side girder to side girder and the cutout is 12½ ft from apron to top. The cutout is concreted over the back and down the lean-to with a minimum of 1 ft of concrete. Side girders are formed and poured with 65-lb rails imbedded in the concrete for wear.

A 4x6-ft manganese steel drawhole frame is installed on the center line of the slusher drift and held in place by four 1½x5-in. countersunk bolts on each side.

On the hoist side of the drawhole the second apron is placed on an incline with 60-lb rails welded on the center line of the plate, which is supported and cushioned by a 12x12-in. timber. The plate is on an angle to enable the operator to watch the ore cars and keep rock from building up around the slusher.

After the concrete has set, the slusher drift is driven 107 ft at 9x12½-ft size. The last round is reduced in size and the bottom brought up on a 45° angle for the installation of the vent slot that connects with the ventilation drift below. The original steep incline of the slusher drift has been reduced to a slope of 3 ft in the 107-ft drift length. Inclined slusher drifts were discontinued, as they limited the operator's visibility and created a dangerous working condition on the lower side of the fingers.

If the rock in the slusher drift is strong enough, the finger excavation is made upon completion of driving. Finger raises are on 33-ft centers along the slusher drift and directly opposite each other. The excavation is on 45° slope, 12 ft wide and 8 ft high. The finger bottom is started 6 in. above the slusher drift bottom.

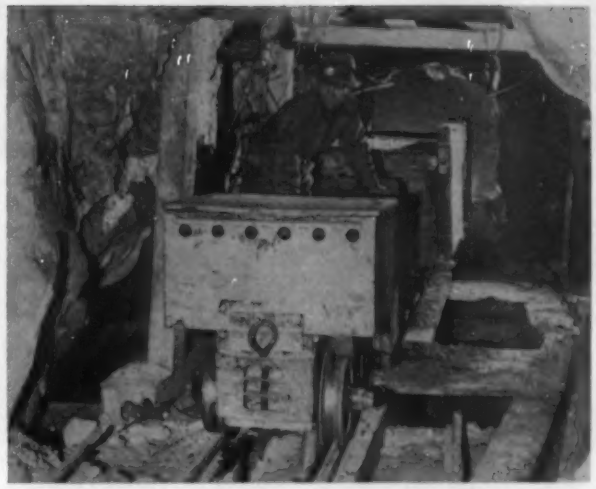
Muck is drawn from the slusher drift under development by a 60-hp slusher mounted on the op-

posite side of the steel hopper. The drift rounds are drilled with two column-mounted 3½-in. drifters using carbide bits and alloy steel. However, airlegs are being used for this job in certain sections of the mine and may replace drifters entirely.

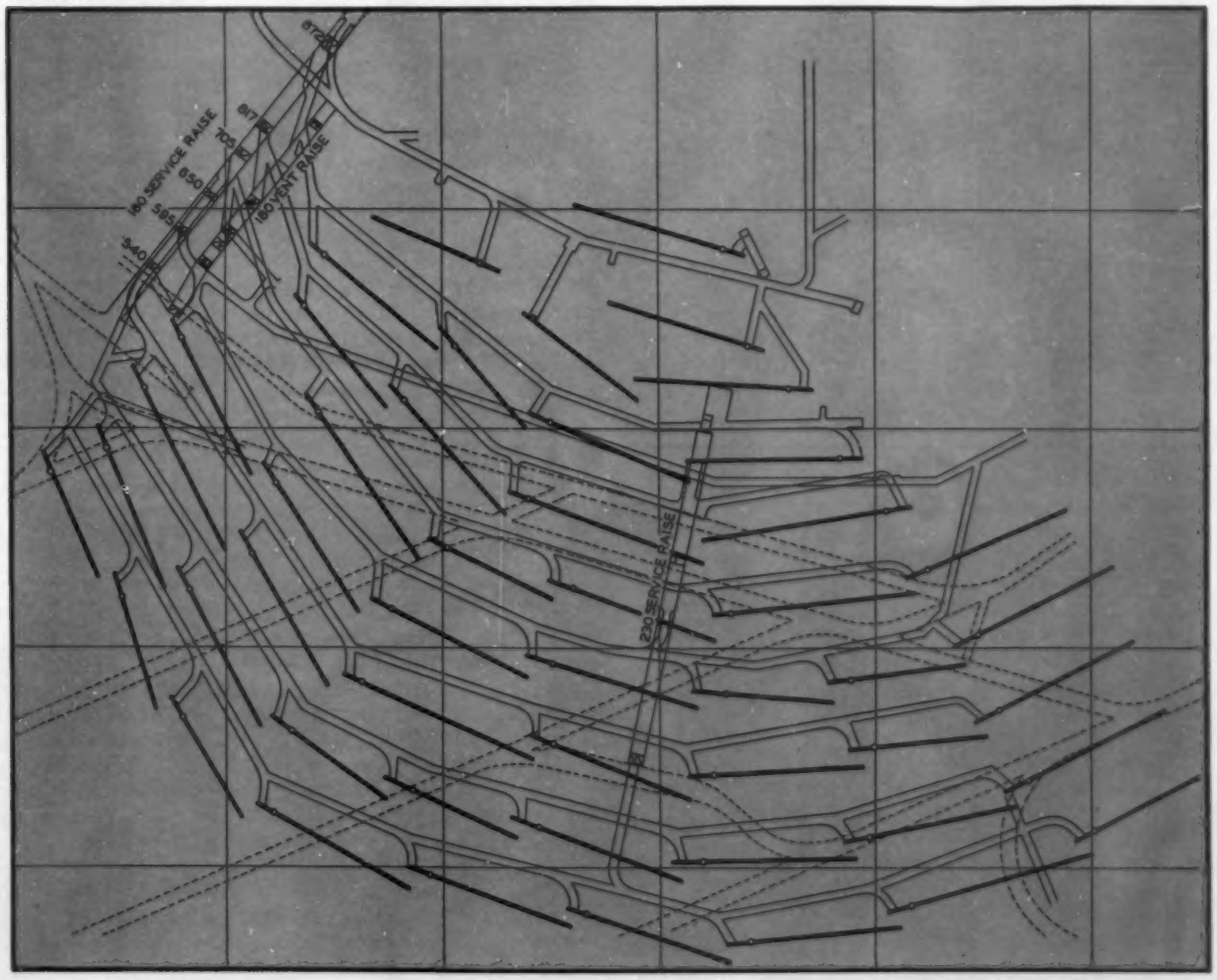
In slusher drifts that require support no attempt is made to cut fingers until the bottom and sections of the drift between the fingers are concreted. To support the drift before concreting, timber sets have been used but roof bolting is now replacing timber with great success. The roof bolts are ¾ in. x 7 ft with an expansion anchor. Used in conjunction with a 2-in. mesh wire fencing, which covers the entire back and 4 ft down on each rib, the bolts give safe back support that does not interfere with forming and concreting. The bolt anchors are unique in that they have a left-hand thread to utilize the rotation of a stoper or airleg for tightening. This method of bolting is fast and effective and uses equipment readily available for the installation.

After the slusher drift and finger excavations are completed, the 14x10-ft slusher hoist cutout is driven 26 ft in from the center line of the loading drift. This cutout is formed and concreted along with the drift and fingers.

The pillars that remain from the undercutting are drilled to complete the stope for final blast and caving. The pillars are drilled with horizontal longholes, four holes in each vertical row spaced 3 ft apart. The two center holes are drilled completely through the pillar, and the top and bottom holes are of equal depth to avoid leaving stubs when pillars are blasted. The bottom holes form a 45° slope for the sides of the funnel to the drawpoint, and the top hole acts as a breaker to promote initial caving action.



Small battery locomotives move equipment and broken rock on service entries of the footwall program. This portion of the orebody lies over the barren core and development is carried out as shown on page 736.



Plan of footwall development showing position of slusher drifts. Drifts vary in length from 112 to 145 ft, but spacing between drifts is held at about 68 ft. Small circles represent the ore pass connection to each of the slushers.

Longholing

Longholing machines are 3½-in. drifters on 4-ft aluminum shells mounted on vertical columns and crossarms. Alloy drill steel couplings and carbide bits have permitted setting up and drilling a wider pillar from a narrower undercut at a reduced cost. Prior to these improvements, undercuts had to be wider than the thickness of the pillar to allow for changing of conventional drill steel.

In order to supply adequate and constant air pressure, 1¼-in. hoses are used on all longhole drilling. Climax has standardized on 2⅛-in. drill bits to provide proper hole size, so the coupling will follow for the life of the bit. The 2-in. bit did not allow for this.

Longholes are loaded with 45 pct semigelatin stick powder and timed with millisecond electric delays. The timing is started from the brow holes over the drawpoint, proceeding upward to the apexes. The order of blasting pillars is to retreat by single rows from the previous cave area. Slushing of blasted ore should follow each blast to allow ample room for the swell from the next shot. This also affords safe inspection for misfires and stubs from the previous blast.

Flexible plastic pipe with a short, wooden loading stick inserted in the end has replaced jointed loading sticks in the narrow undercuts. Smaller plastic pipe has replaced coupled pipe for blowing holes previous to loading. All development blasting is now done electrically using 440 v ac.

When stoping along the hanging and footwall at the edge of the orebody, a cutoff shrink is established by driving 7x9-ft raises at regular intervals to the height of 50 or 75 ft above the stope and pillars thus formed are drilled for blasting.

When stoping is discontinued inside the boundary of the orebody, a boundary cutoff is driven from the top of the undercut through the pillar parallel to the line of the slusher drift to reduce the possibility of drilling into missed holes when resuming undercutting in the adjoining stopes.

Concreting

The newest slusher drift bears little resemblance to the 1933 model. The first drifts were designed with the idea of handling larger material with more speed, safety, and efficiency than possible through the use of chutes and grizzlies. In the development of slusher drifts, it was found that the rock itself was not capable of standing the abrasiveness of the ore running through the fingers, concussion from the secondary blasting, and the wear of the dipper as it moved back and forth in the drift. The brows of the fingers broke out so high that the flow of rock could not be controlled. In many cases the muck completely filled the slusher drifts and operation became dangerous and costly. The slusher drift bottoms wore deep and the walls wore wide.

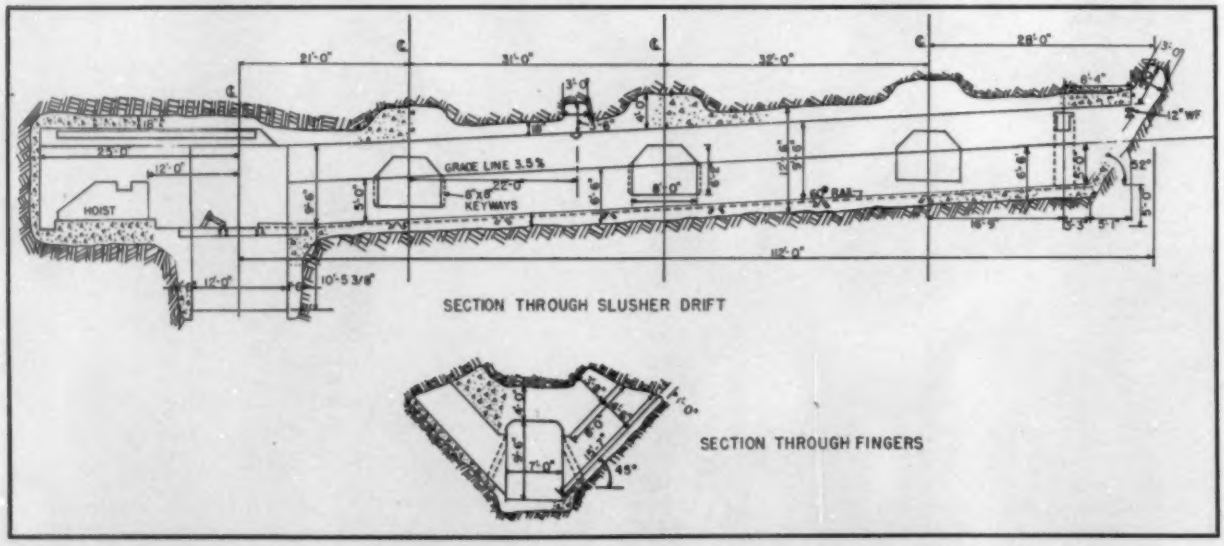
Many types of support were tried at the brow of the finger, including timber sets, logs with steel-wearing plates, and steel sets made of heavy box beams. None of these proved satisfactory and in 1939 concreting was started to provide ground support and to provide a finger brow at the slusher drift that would control the flow of ore.

To prepare the concrete for underground use, sand and aggregate are elevated into a hopper at an outside batching plant. This material is then weighed and dumped into individual compartments of the aggregate cars. Each car has 24 compartments each containing enough aggregate for a ½-cu yd batch of concrete, and a conveyor belt under the compartments of the car dumps the aggregate into the mixer hopper. At present, sacked cement is added by hand at this point, but the bins and aggregate cars are being altered to handle bulk cement to eliminate this hand operation. From the mixer, the concrete is elevated into a Pumpcrete machine by a conveyor belt and pumped through a 6-in. line into the forms.

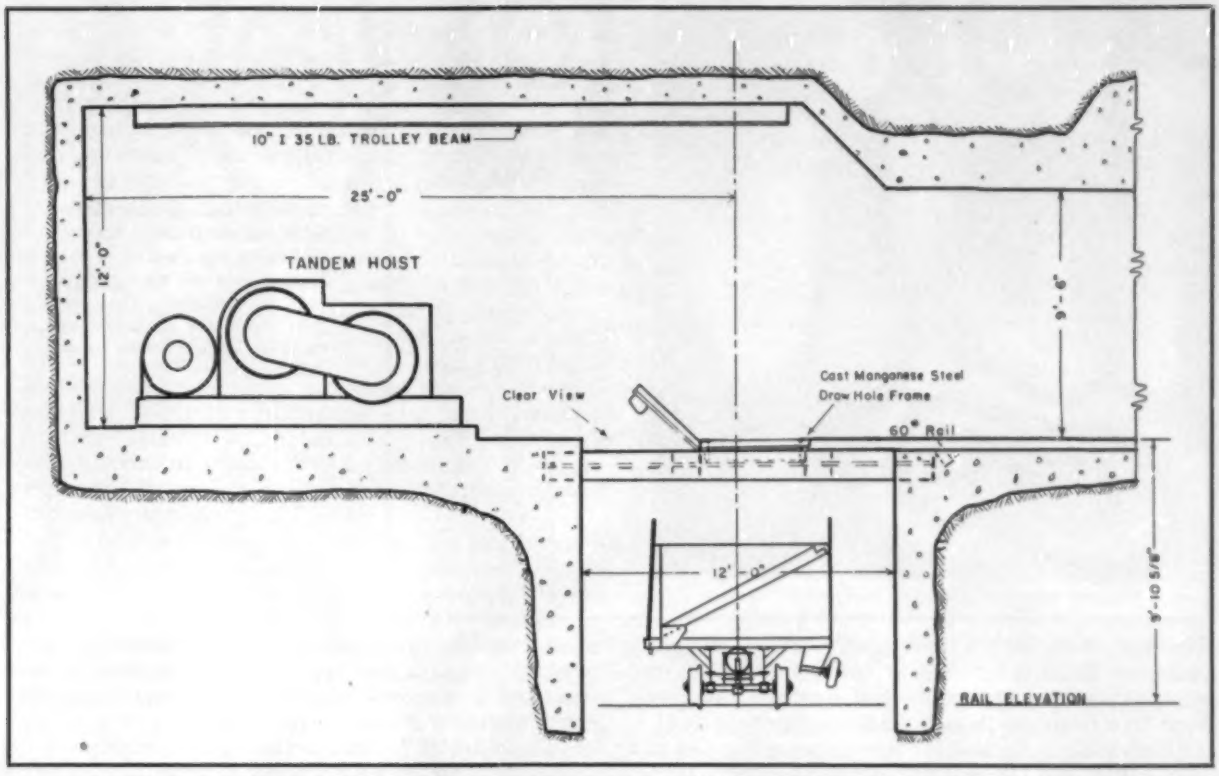
All the underground concreting equipment is adapted to 36-in. gage track and the power for operation is 440 v ac.

Steel Forms Reduce Concrete Costs

Wood forms were built for the first concrete work done in slusher drifts. This was economical while the design of the slusher drift and fingers was going through the many changes. Steel forms were purchased in 1947 for slusher drift concrete work and have been made standard items of equipment. Standardization of the cutout legs in the haulage drift and end log section has permitted steel forms to be used throughout. A truck-mounted form jumbo similar to that used to pour tunnel linings is used in the haulage drift to form the cutout legs.



Details of concreted slusher drift. Numerous variations have been tried, but this construction has given the most satisfactory service. A sill slusher requires 500 to 800 cu yd of concrete depending upon the overbreak.



Design for standard single-end slusher drift hoist cutout showing beam for monorail chain block used to change hoists and hoist parts. Inclined frame left of drawhole gives operator clear view of car as well as deflecting excess rock.

These legs are poured to a height that will allow the drawhole steel to be placed, formed in, and poured with the cutout. The loading cutout is also poured with steel forms. The top of the finger forms are now poured full using steel forms and remined through the thin section of concrete. Previously these were formed by wooden bulkheads that tapered from the steel forms to the rock. Steel forms used in the end log section have been designed to hold in place the 133-lb H-beam for the tail sheave anchor.

Formerly, concreted floors were poured with eight parallel 60-lb rails welded together for the length of the drifts. As the dippers increased in size and weight, rails were quickly torn out. Newest floors are poured with a series of parallel rails. The end of these rails are turned down on a 45° angle, and embedded in concrete which is poured to the ball of the rail. The slusher drift has to be driven 1½ ft below the finished grade to allow for this installation.

After the bottom has been poured, the steel forms are put in place for the slusher drift and fingers, including the H-beam anchor for the tail sheave, the idler sheave in back, and the 20x20-in. ventilation box. The finished drift has at least 1 ft of concrete in the walls and 1½ ft in floor and back. When the fingers are reamed, extra ground is taken out of the back to allow for 3½-ft minimum of concrete at the brow. This is the important control point and must be maintained for the life of the finger.

Finger design has been changed frequently. The present fingers are concreted 8 ft wide, 4½ ft high, and 8 ft long with the bottoms and backs on a 45° slope. The bottoms extend 5 ft beyond the vertical plane of the concreted backs to aid in eliminating hang-ups. The backs of the fingers are arched to correspond with normal wear. Most rocks that enter the unconstricted finger come through without blasting. The bottoms of the fingers are raised 6 in. above the drift floor to prevent choking in the fingers.

The ribs of the slusher drift are reduced to 4 ft just in front of the tail sheave to protect the sheave from damage. The ventilation duct between the slusher drift and the ventilation drift has slots concreted into it to allow for closing the opening if the drift is not being worked.

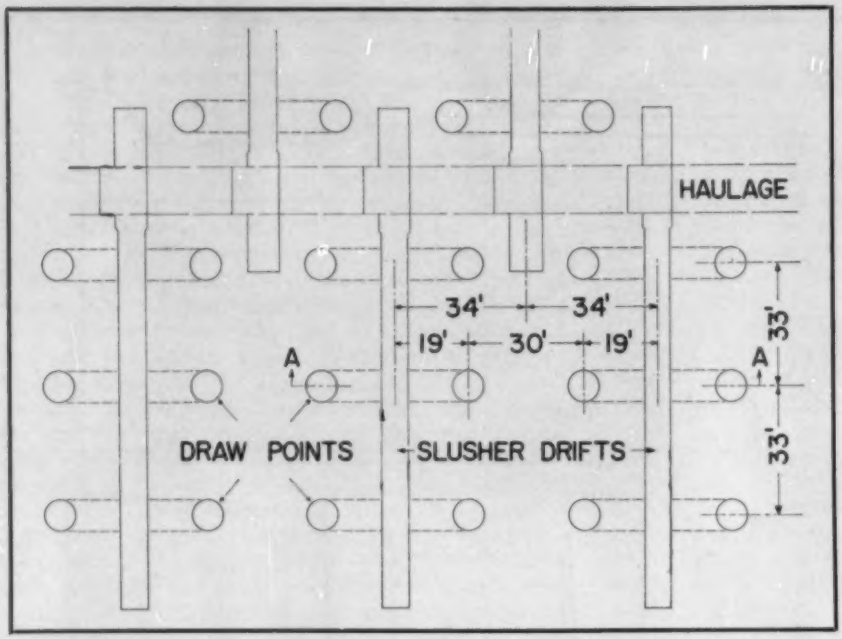
Production

Design of the slusher drifts and the operation of slushing equipment constitute one of the most important phases of the operations. Ventilation, control of ore, secondary blasting, wear, maintenance of equipment, safety, efficiency, and speed of loading are vital considerations.

The original double-ended slusher drifts with center-mounted hoists did not allow for proper ventilation, visibility, draw control, protection of slushing equipment, or support of hoist. To improve this situation, the slusher hoist was mounted in the slusher drift opposite the side to be drawn, approximately 15 ft back from the center line of the drawhole. This improved the visibility, enabled handling large rock, improved ventilation, cut down on maintenance of equipment, but did not allow both sides to be drawn without changing the slushing equipment to the other side of the drift. In an endeavor to answer these problems satisfactorily, further development was planned for single-ended slusher drifts with closer spacing. This has proved to be satisfactory in all respects.

The newest and most satisfactory hoist for slushing is a tandem two-drum hoist powered by a 150-hp high-slip motor. The hoist has a 17,000-lb rope pull at a rope speed of 280 fpm with the drum half full.

The nose and tail drums are equipped with snubber brakes to avoid excessive backlash of the cables.



Layout of haulage and slusher drifts for sill mining. Ventilation drifts are parallel to the haulage and at the opposite ends (not shown). The vent drift serves the slushers from the next haulage. Note drawpoint spacing.

The tail drum is also equipped with a manually operated hand lever that is connected to the tail snubber brake. The cable can be tight-lined and kept free from ore flow when fingers are blasted.

Used cable is stocked for these hoists. The tail and nose cables are 1⅛ and 1¼-in. respectively. On 15 hoists checked, a set of cables averaged 27,798 tons before being replaced.

A 6-ft folding hoe-type scraper, developed at Climax, is used for loading. The scrapers are 56 in. high when opened and 26 in. when folded. The operator can control the opening and folding action with the slusher controls. When going toward the tail sheave, the folded scraper rides over the ore in the slusher drift rather than pushing it back and causing damage to the cables and tail sheaves. The combination of a 6-ft scraper size in a 7-ft slusher drift corresponds to tests for greatest slushing efficiency and prevents ore building up at the mouth of the finger.

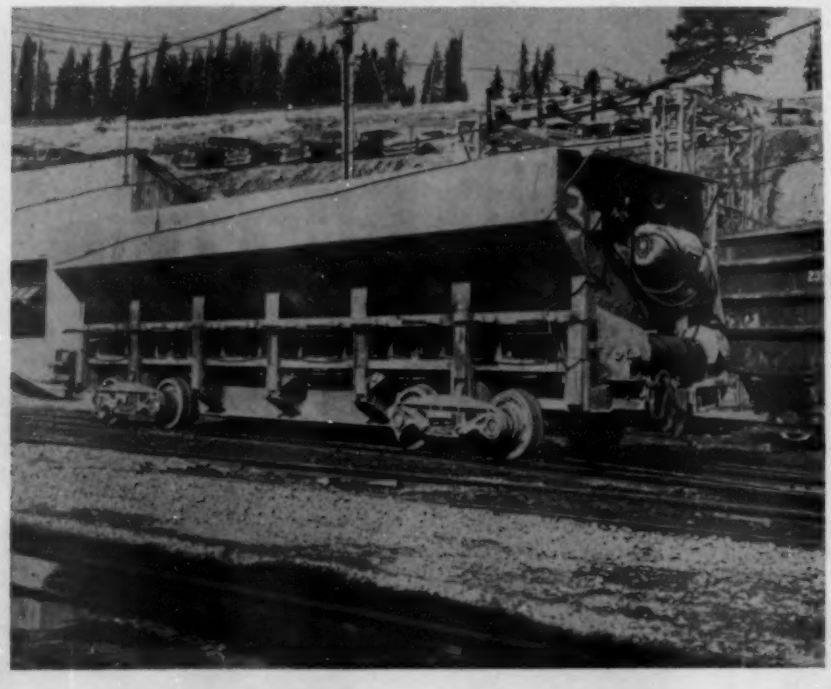
To protect the operator from cable breakage, a swinging gate made from 1 and 2-in. pipe is hung in front of the operator. The guard allows satisfactory visibility and ample protection.

There are 99 production hoists in operation on the Phillipson and 28 production hoists on the Storke. In 1954, 5.3 million tons of regular grade and low grade ore combined were produced on the Phillipson level for an average of 145 tons per production manshift. Production manshifts include bulldozing, loading, haulage, dispatchers, and outside car cleaners. During the same period the Storke level produced 3.4 million tons for an average of 256 tons per production manshift.

Haulage

Two most important improvements in haulage in recent years were the introduction of radios in the haulage system and addition of improved haulage motors.

The Phillipson level has been in production since



Underground batch car carries sufficient aggregate for 24 mixes of concrete. Each compartment can be released individually on the conveyor belt that runs full length of the car. The belt unloads into mixer hopper which in turn feeds the Rex Pumpcrete machine.

1931 and the Storke level since February 1953. The loading areas on both these levels are reached by single track adits more than 3000 ft long. Track gage is 36 in. with 90-lb rail in the portals and outside. Underground haulage rail is 65 lb. Dispatchers are stationed at each end of the adits, controlling the mine railroad traffic with electric interlocked controls. Empty ingoing trains are dispatched through the footwall or fringe drift into the proper haulage drift for loading. In addition to telephones, each dispatcher has a radio that enables him to be in contact with all the motor crews. After the train has been loaded, it proceeds to the hangingwall or fringe drift and is dispatched outside to the crusher. From the time the trains leave a loading drift until they return to one, they are under control of a dispatcher. The trolley radio units have improved production efficiency and aided safety by the ease with which trains or motors may be dispatched to working areas. Closer supervision is also possible through this service.

The trolley radio units at Climax are FM carrier-type radios and to avoid confusion between haulage levels, the frequency on the Phillipson level is 100 kc and on the Storke level is 61 kc. Radios are shock-mounted in the cabs to withstand concussion and vibration. All component parts are plug-in type. The only service equipment needed is a volt-ohm meter and a tube tester, and with a minimum of instruction anyone can service the sets. Blast-proof speakers proved inadequate for protection, and a concussion grill was developed to prevent damage.

New 36-in. gage locomotives added to the system weigh 27 tons and were designed specifically for the Climax operation. Locomotives are 4-axle, double truck units, 420 in. overall length without couplings, 59 in. wide and 80 in. high and have a maximum drawbar pull of 13,750 lb. Operating control is electro-pneumatic, actuated by solenoid valves with air control. Units are equipped with both dynamic and air brakes. Air brakes have separate valve control for the motor only or for motor and train. The motorman's enclosed cab is in the center of the locomotive with 360° visibility. Included in the cab are the power controls, air brake valves, dual pressure gages, emergency hand brakes, trolley-radio transmitter and receiver, and cab heaters.

All locomotives are equipped with sealed-beam lights and air horns. Experience shows that good visibility and warning signals are essential to safe haulage. All switch stands and signs used to direct train movement are made from reflectorized paint or paper. Electrically controlled derailers are used as safeguards to prevent train crews from running red lights and to stop trains that are out of control. All signals, derailers, and electric eyes operated by the dispatcher are from the interlocked control board.

The new 27-ton motors pull trains of 24 cars while the older Atlas 20-ton motors handle 20 cars. The car factor on Phillipson level is about 8½ tons, and on the Storke it is 9 tons. Here again, the smaller breaking ore on the Storke is a definite advantage.

The Phillipson level works three shifts on production with seven trains on the run and a trade train outside. Storke level production is on two shifts with three trains on the run and a trade train outside.

Ventilation

Ventilation of the Phillipson level was effected after the mining of this area was completed, whereas the ventilation on the Storke level was carefully laid out and was installed at the same time the slusher drifts and haulage drifts were driven.

Two-drum tandem hoist is rapidly becoming standard equipment for production slusher drifts. Being considerably narrower than the older hoists, a substantial saving is realized in the reduced width of the slusher hoist cutout.

Fresh air is brought to the Storke level through a 152-sq ft section ventilation raise. The 96-in. Axivane-type intake fan operates at 1-in. water gage and delivers 200,000 cfm. This fan discharges into a ventilation lateral that parallels the hangingwall. Ventilation overcasts are built at approximately right angles to the haulage drifts and are used to direct the flow of fresh air into the haulage drifts that are being worked.

At the opposite end of the block, an exhaust ventilation lateral parallels the footwall drift and contaminated air is exhausted to the surface via an exhaust raise 230 sq ft in area. The exhaust fan is a 108-in. Axivane-type fan delivering at the present time 200,000 cfm. The ultimate duty of this fan is to be 350,000 cfm. Where the individual exhaust drifts intercept the haulageway, the overcasts are sealed to prevent contaminated air from being recirculated throughout the mine.

Midway between and parallel to the loading haulage drifts are 5x7-ft ventilation drifts driven at haulage grade and elevation. Slusher drifts are connected to this ventilation drift by a short raise near the end log and a 20x20-in. concreted box. This allows one ventilation drift to exhaust air from the slusher drifts on the south side of one loading haulage drift and from the slusher drifts which are on the north side of the adjacent loading haulage drift.

The fresh air furnished under pressure in the loading haulage drifts enters the slusher drift through the lean-to and the drawhole, thus keeping the hoist operator in an area of fresh air. The action of the exhaust fan draws the air to the rear of the slusher drift and through the ventilation box and raise into the exhaust ventilation drift, from there to the main exhaust drift, to the fan, and up the surface raise to exhaust to the surface.

In conjunction with the ventilation, each slusher drift is furnished with an air-water blast spray which is turned on when blasting is done. This makes it possible for the operating crews to return to the slusher drifts immediately after secondary blasting.

MILLING operations at Climax started in 1918 with a 200-ton flotation plant. At that time the crusher was located at the mine and ore was delivered to the mill on a tramway. The plant closed down in March 1919 and remained closed until 1924, by which time a modest demand for molybdenum had been developed. From 1924 to 1932 the mill capacity was increased to 1200 tpd, and mill sections added in 1932 increased capacity to 4000 tpd. In 1936 and 1937 six additional mill sections were built, bringing the designed tonnage to 10,000 tpd. One more section was added in 1940. This together with improvements in grinding technique increased tonnage to 18,000 tpd. The most recent expansion program includes six more mill sections and the Storke level crusher. Present capacity is 28,000 tpd.

Crushing Done in Three Plants

Crushing of Climax mine-run ore is carried out in three stages. No. 1 and 2 crushers are used for ore from the Phillipson level and the No. 3 crusher treats ore from the Storke level. The flow of materials is the same in all three, but the third stage of crushing for the Storke level crusher is done in No. 2 crusher.

Equipment in No. 1 and 2 crushers is identical, but the capacity of No. 1 crusher is 5000 tpd while the capacity of No. 2 crusher is 14,000 tpd.

Phillipson ore is dumped into the crusher bins from 10-ton Granby cars and fed to 48x60-in. Buchanan jaw crushers through chutes and Ross feeders. The jaw crushers have a discharge opening of approximately 9 in. and a capacity of 500 tph each. The product from these jaws is carried by pan and belt conveyors to a 5x9-ft vibrating grizzly with 1½-in. openings. The oversize is fed to 7-ft standard Symons cones and the undersize joins the crushed material from the standard. The standard cone crushers are set at 1⅛ in. on the closed side and the product, all −3 in., is fed to storage bins. Operating in closed circuit with vibrating screens, 7-ft shorthead Symons cones prepare the final mill feed, averaging 6 pct on ⅜-in. mesh.

Storke Level Crusher Designed to Handle All Mine Production In Future

Several proposals for handling the production from the Storke level were considered. One of the most interesting was the underground location of a primary and secondary crusher using belt conveyors to transport the ore to No. 2 crusher. However, the most practical and least expensive solution to the problem was a new surface installation about 1500 ft from the portal.

The Storke level crusher is designed to crush the entire mine production after the ore from the Phillipson level is depleted. The primary crusher at the Storke level is a 60-in. Nordberg gyratory. The main shaft complete with mantles weighs 90 tons and the total weight of the crushing unit is 500 tons. The crusher is driven by a 500-hp motor with a V-flat pulley arrangement. Countershaft speed is 240 rpm, driving the eccentric at 80 rpm. To guard

Frank Windolph and Max W. Dessau
Assistant Mill Superintendent and Mill Superintendent

New Storke level crusher located 1500 ft from the Storke level adit, which is to the left of the picture on the same elevation.

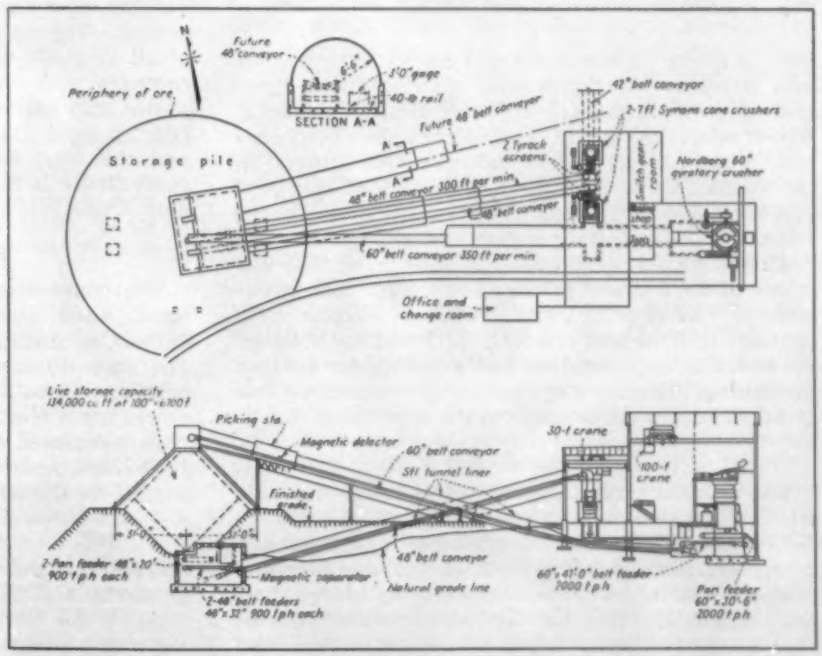
against oil failures the crusher is amply protected by flowmeters, high-low temperature gages, and pressure gages. These protective devices are interlocked with the drive motor so that any oil failure will stop the crusher. The machine cannot be started until the cause of failure is corrected. This crusher was started in February 1953 and to date neither the mantles nor the concaves have been worn out. However, the practice of welding manganese steel bars to the lower mantle appears to be profitable. This crusher has a capacity of more than 2000 tph and delays due to large rocks are negligible.

This compares to about 20 pct lost time because of large rocks and hangups in crushers and bins.

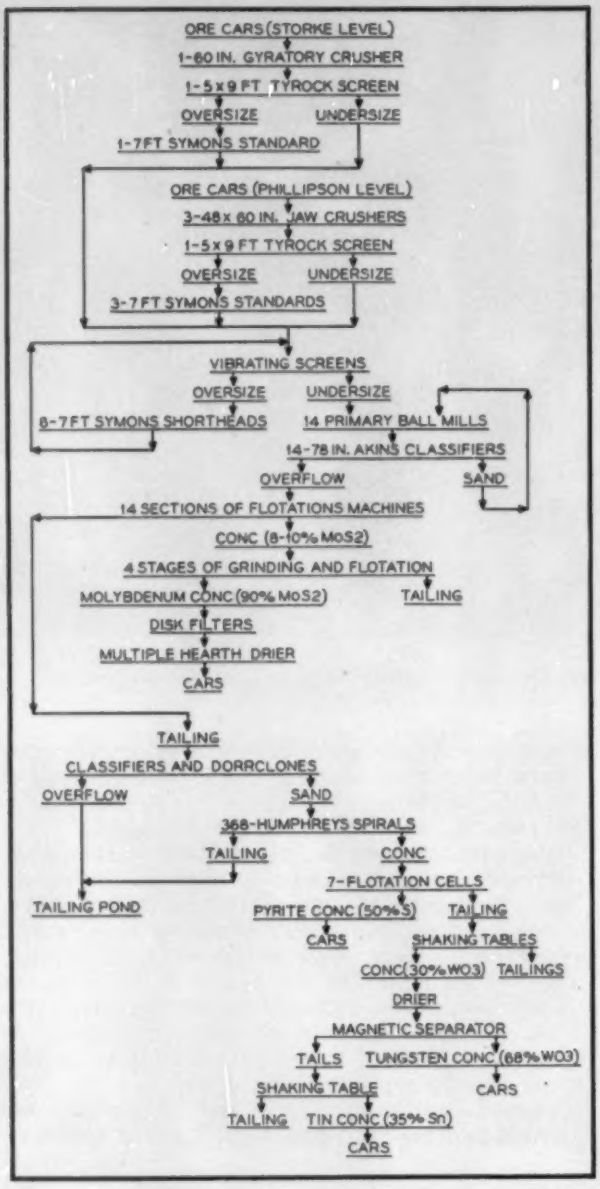
Ore from the primary crusher is stored in a coarse-ore bin adjacent to the crusher building. From this bin the ore is fed on a 5x9-ft vibrating screen, with 2-in. openings. The oversize product from the screen is crushed in a 7-ft Symons standard cone and added to the screen undersize.

The product from Storke crusher is transported nearly 4000 ft and elevated more than 300 ft to the fine ore bins near No. 1 and 2 crushers. This conveyor system is divided into belts of nearly equal length operating 475 fpm. Designed capacity is 1500 tph. The ore from the fine-ore bin is delivered to the storage bins in No. 2 crusher for the final stage. The crushed ore from all three crushers goes to 14 cylindrical ore bins, 35 ft high and 35 ft diam, having a capacity of 600 *live* tons of ore.

Climax ore is an altered and highly silicified granite, and the most important mineral, molybde-



Many features are incorporated in the new Storke crusher, including bins constructed with earth fills and outside conveyor belts enclosed with semicircular corrugated-tunnel support. This crusher will handle all mine production when mining on the Phillipson is complete.



← Flowsheet of Climax mill

nite, is finely disseminated and found in thin veins and stringers associated with quartz. Other minerals present in the ore are wolframite, cassiterite, topaz, monazite, pyrite, and calcopyrite. Molybdenite is not difficult to float; however, the mineral in the Climax ore is very finely disseminated and good recovery at coarse grinds is one of the major problems. At present, the rougher concentrate is being floated at 43 pct +100 mesh. It is believed that this is one of the coarsest grinds of any large mill is existence. The ratio of concentration of rougher concentrate to total feed is nearly 25:1 and the rougher concentrate only requires fine grinding for further processing. This system confines the expensive fine grinding to a small amount of the total feed.

Rougher Circuit

The rougher circuit consists of 14 units in parallel. Each unit is made up of a bin, ball mill, classifier, three 13-cell flotation machines, and auxiliary equipment such as feeder belts, pumps, and blowers.

There are eight 9x8-ft grate-type Marcy ball mills driven by 450-hp motors and six 9x9-ft grate-type Marcy ball mills driven by 600-hp motors. The use of shiplap liners is standard practice and 3-in. forged steel balls are charged daily. Consumption of balls is 1.30 lb per ton of ore treated.

The classifiers are 78-in. Akins duplex high weir, with a double spiral. The first of these classifiers had 12-in. shafts, but recently completed installations have 16-in. shafts and it is felt that this increase in diameter will reduce shaft breakage. The circulating load is about three to one.

Although several types of flotation machines have been tried, the standard equipment is the Weinig subaerated hog-trough type. The power requirement for this machine is less than 1.0 kwhr per ton and air at 1¾ psi is used at the rate of 35 cfm per spindle. Normally the flotation circuit consists of three 13-cell flotation machines in series. The froth from the first machine is the rougher concentrate and the froth from the second and third machines is returned to the first. The reagents used in this circuit are:

Reagent	Lb Per Ton
Hydrocarbon	1.00
Syntex	0.02
Pine oil	0.05

Cleaner Circuit

The rougher concentrate, containing 8 to 10 pct MoS_2, is thickened and then cleaned in four stages of flotation with grinding and classification between each stage. The first stage grinding in the cleaner circuit is done with two 5x20-ft mills charged with ¾-in. forged steel balls.

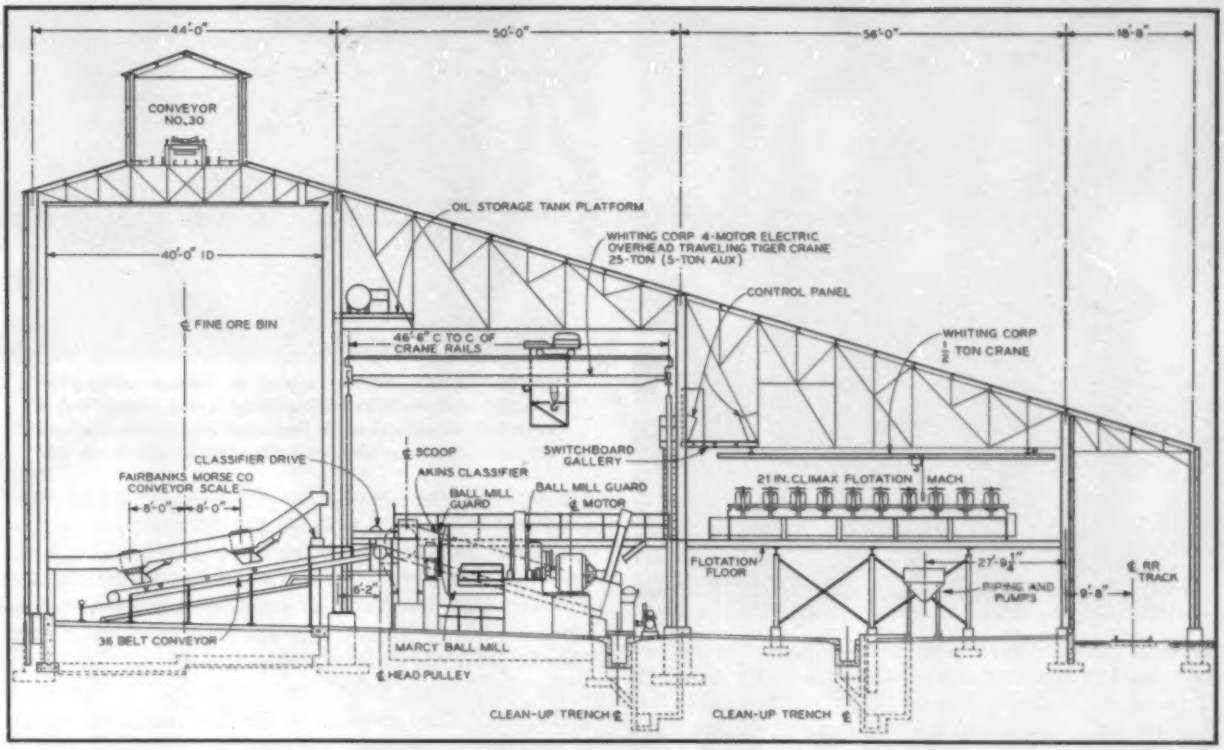
Second stage grinding is done with two 8x20-ft mills charged with 2 to 3-in. Texas pebbles. The final two stages of grinding use one 8x20-ft mill each, and the same pebble size as the second stage. Very fine grinding with flint pebbles seems to have no ill effect on subsequent flotation, but the same amount of work with steel balls will lower the recovery. The only reagents used in this circuit are small amounts of pine oil to promote molybdenite recovery, and soda ash with cyanide to depress the pyrite and calcopyrite. This cleaning circuit is in effect a complete mill in itself from which a tailing and the final concentrate is produced. Grade of concentrate is easily maintained and recovery seldom drops below 98.5 pct.

Filtering and Drying

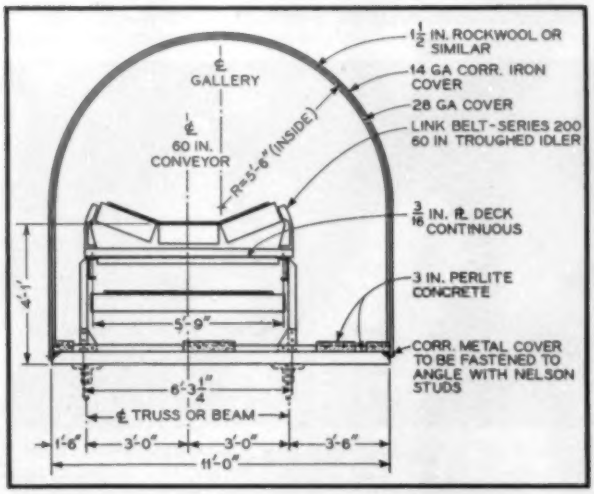
The concentrate from the cleaning plant is filtered, dried, and finally loaded in hopper cars or barrels, according to the demands of the customer. The recently completed filtering and drying plant consists of two 6-ft Eimco disk filters. The filtered concentrate feeds a 20-ft four-hearth drier. The system replaced four drum-type filters and four oil-fired Lowden driers. The new scheme not only improved results but also reduced costs.

Byproducts

Finely ground tailings from the cleaning plant go to waste, and the coarse tailing from the rougher circuit is the feed to the byproducts plant. The most important mineral recovered from the rougher tail-



Cross-section of No. 3 Mill



Section through an exposed conveyor gallery, showing insulation and lightweight construction. The curved corrugated covering is used for highway culvert support. Electric strip-heaters are installed in the gallery to keep temperatures above freezing in the winter.

ings is wolframite, but some cassiterite and pyrite are also obtained.

The presence of extremely small amounts of wolframite in the ore had been known for many years, but no economical method for its extraction was known until after the development of the Humphrey spiral. Test work was started with spirals in 1946, a pilot plant was built in 1947, and finally a 7000-ton unit was placed in operation in 1948.

This section of the mill has increased in size along with the rest of the plant, although the byproducts plant is overloaded at the present time. The flow of materials now used has evolved from the original 7000-ton plant and consists of spiraling classified products, removing pyrite by flotation, tabling the nonfloat from the pyrite flotation, removing monazite from the table concentrate by flotation, and upgrading WO_3 concentrate with magnets.

The Humphrey spiral is the key to the successful operation of the byproducts plant. The feed to the spirals contains about 0.025 pct WO_3 and the spiral concentrate contains 1.0 pct WO_3 after cleaning. Tonnage to each spiral is 40 tpd. Recovery of the spirals is nearly equal to table recovery, but tonnage is double and requirements for floor space are about 40 to 1 in favor of the spirals.

The spiral concentrate contains about 50 pct pyrite which is removed by flotation in an acid circuit with xanthate, pine oil, and Dowfroth. A clean pyrite concentrate containing not less than 50 pct sulphur is produced and sold for acid manufacture.

The nonfloat from the pyrite flotation is tabled and the concentrate, containing about 25 pct WO_3, is fed to the monazite removal section where monazite is floated in a high acid circuit using amine to promote the monazite and starch to depress the wolframite. The nonfloat from this circuit, containing about 40 pct WO_3, is upgraded on magnets to 65 pct WO_3. The nonmagnetic material contains the tin, which can be upgraded by tabling or screening.

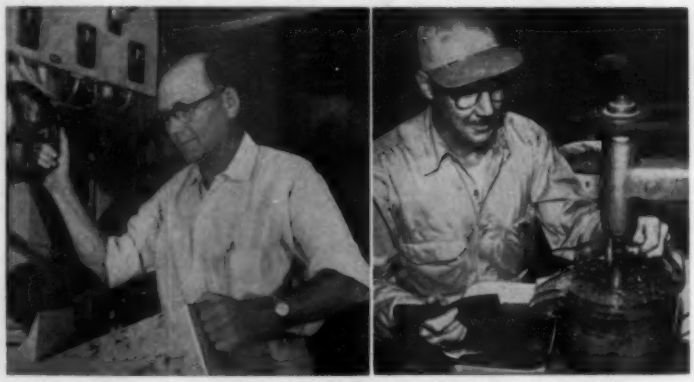
The tailings pond, located about three miles north of the mill, serves two purposes—tailing storage and water reclamation. Tailing is carried from the mill through 24-in. wood stave, machine-banded pipe. The crest of the present pond is 300 ft lower than the mill. The pipeline is laid in nearly horizontal sections, each succeeding section being at a lower level. The horizontal sections are connected by vertical drops open at the top. The length of these sections and the height of the vertical drops conform to the topography and are arranged so that each 1000 ft of horizontal pipe has at least 15 ft of

ABOVE—Looking northwest across the Climax tailing pond. In foreground is 24-in. tailing line showing standard drop for maintaining head in the line. LEFT—Six-pole magnetic separator producing tungsten concentrate in byproducts mill.

vertical drop. These penstocks impose the necessary head to maintain the minimum velocity required to carry the tailings. During the summer months the tailings are distributed along the crest of the dam through 4-in. leads. The height of the berm built in this manner is raised still higher with bulldozers. During the winter the tailings are distributed through four or five 20-in. leads in front of the berm built during the summer. The water impounded in the dam goes by gravity or is pumped to Robinson Lake. This lake, located 3½ miles from the mill and 600 ft lower, makes up the mill water supply. The lake is filled in the spring by a system of canals that gather the spring runoff from the Ten-Mile watershed. During the winter, overflow from the tailings pond goes by gravity to Robinson Lake, but the seepage from the pond must be pumped. Consumption of water in the mill is about 1000 acre-ft per month, and since the capacity of Robinson Lake is only 2000 acre-ft, conservation of water is extremely important.

Beneficiation

Climax Expands Ore Treatment Research



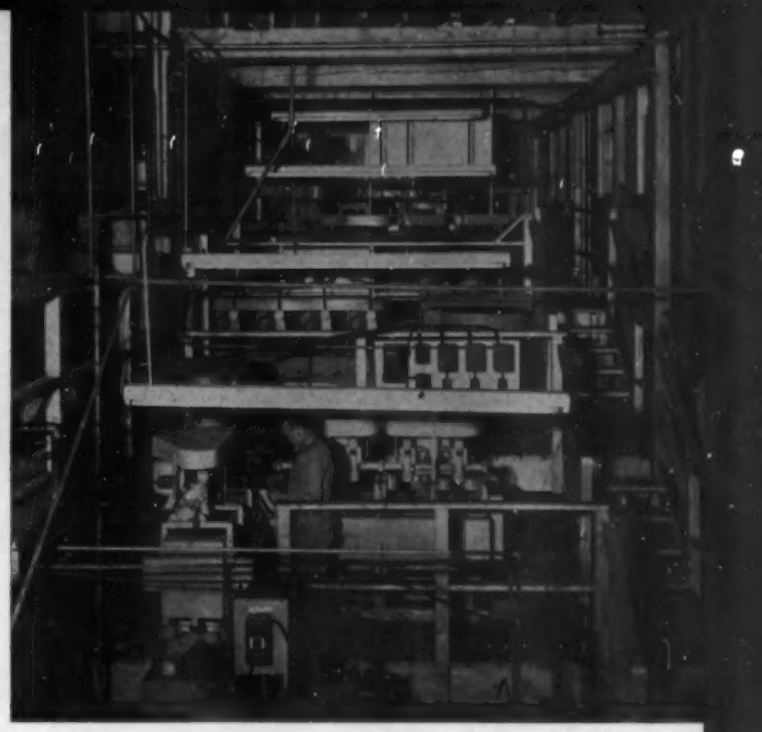
R. E. Cuthbertson and Fred J. Hoff

Research Engineer and Research Metallurgist

AS a part of its western operations, Climax, since 1926, has conducted a program of ore testing at the Golden laboratory of the Colorado School of Mines Research Foundation, which is staffed with a technical group directly employed by the company. Exclusive use of certain laboratories together with the joint use of all common plant facilities is established by contract with the Colorado School of Mines Research Foundation. The Foundation is a nonprofit corporation legally distinct from the Colorado School of Mines but closely associated with the school. The experimental plant, center of activities of the Research Foundation, is school property but is primarily used for research work sponsored by the mining and metallurgical industries.

Recent expansion by Climax of research activities in the ore dressing field is the result of definite company policies. In the first place constant effort is being made to achieve maximum recovery of molybdenite and to produce concentrate of highest possible purity. Second, the management-inspired investigation of the recovery of byproduct minerals, which led to the installation of a plant in 1948 for recovery of tungsten concentrate, is still a very active undertaking. Third, new and varied demand for ore treatment investigation has been injected into the research program by the exploration dept.

Expansion of the volume of research work has been accommodated by increasing the Golden laboratory staff and establishing a new testing labora-



ABOVE—Pilot plant in Golden laboratory for testing magnetic separation used in Climax byproducts plant. RIGHT—Molybdenum flotation test mill to check recovery and methods for possible application to the Climax flowsheet.

tory at the Climax mill, which operates as a division of the mill dept. A number of special projects have been placed with research institutions and universities to supplement direct company effort. These sponsored investigations in ore processing are carried out either under the direction of the company laboratories or under the general supervision of a company official who coordinates such work with the activities of testing staffs at Climax and Golden.

Mill Laboratory Attacks Operating Problems

The metallurgical research program was expanded in August 1954 by the installation of laboratory facilities at Climax. Being located at the plant, the laboratory personnel have access to the various plant pulps. This makes it possible to carry on investigation for the possible improvement of existing processes involving the recovery of molybdenite, tungsten, pyrite, and tin.

Initial molybdenite flotation testing confirmed previous work by the Golden laboratory that there was a considerable spread between the recoveries obtained in the laboratory batch flotation cell and the plant flotation cells. Laboratory tests resulted in higher recoveries. It was possible to cut this recovery loss almost in half by changing the plant flowsheet to conform with the laboratory procedure. This new procedure decreased the grade of rougher concentrate about 2 pct as a result of a flowsheet change that sent all froth to rougher concentrate instead of recirculating the middling fraction back to the head of the circuit. Froth removal must be controlled at a slow rate to hold rougher concentrate tonnage and grade within limits of the regrind-cleaner section of the mill.

The remaining difference in recovery is attributed to the ability of the laboratory flotation cell to float a coarser middling particle than can be floated in the plant machines. As this difference in coarse particle flotation is believed due to mechanical aspects of the flotation cells an investigation is being initiated in conjunction with the operating staff in an effort to improve the performance of the plant flotation cells.

Climax Sponsors Outside Research Investigations

Climax management has adopted an aggressive policy of placement of research projects with institutions outside the company. From an ore treatment standpoint, investigations have been undertaken or are in progress covering a wide range of subjects. A sampling of such sponsored projects illustrates the variety and extent of such work:

1. Colorado School of Mines Research Foundation: Tungsten recovery by flotation, gravity concentration, and by high intensity wet magnetic separation. Chemical treatment of uranium ores.
2. Denver Research Institute (University of Denver): Special spectrophotometric determinations of tungsten; X-ray fluorescent procedures in special analytical problems.
3. Pennsylvania State University: Polarographic determination of tungsten; flotation studies on tungsten.
4. Massachusetts Institute of Technology: Flotation characteristics of the tungsten mineral; spectrographic determination of tungsten.
5. American Cyanamid Co.: Courtesy research on flotation of the nonsulphide mineral molybdite.
6. Southwestern Engineering Co.: Flotation of tungsten.
7. Hall Laboratories Inc.: Contaminants in the mill water supply.

Expert Analytical Work Essential to Research

By way of illustrating the nature of the analytical problems posed by ore treatment investigations a few figures are given from actual experience. Climax ore averages about 0.5 pct MoS_2 or 0.3 pct sulphide Mo. Consequently, a 1.0 pct improvement in recovery is measured by a lowering of mill tailing assay for MoS_2 content amounting to 0.003 pct. Obviously it is necessary to obtain reproducibility of assay results within that limit if test work is to have any significance.

In the case of tungsten a difference in tailing assay of 0.001 pct WO_3 measures a difference in recovery of approximately 4.0 pct. Accuracy of about this order has been achieved on low assay samples by the development of a special colorometric method for tungsten, which makes it possible to evaluate test work within the limits indicated.

Exploration activities also create some interesting analytical problems since ores of many types and from many localities flow into the research laboratory. So long as the engineers and geologists in exploration remain active there is little chance that the research laboratory will curtail its functions.

Auxiliary Departments

Planning

and

New Construction

Max Gelwix and J. W. Goth

Planning Engineer and Metallurgist

THE planning dept. functions as a service department, its existence justified by the aid it can give operating departments throughout the plant. This aid comes through testing and selecting equipment and materials; plans and estimates for construction work; determining the merits of suggestions from various sources, which may range from management to the laborer; and working out methods of operation which are superior to past methods from a standpoint of time, economy, or safety. All of these things are of importance to the operation and help the production man who does not have sufficient time to investigate the necessary details.

At present this department is composed of a planning engineer, a metallurgist, a mining engineer, three test engineers, and a secretary. Problems handed to these men cover a wide range of activity and may come from any department head or from management. The group is working on installation of a mill crane; converting from sack to bulk cement in the mine; building a jumbo and steel forms to replace wooden forms for loading cutouts; converting the main warehouse storage from wooden to all-steel construction; providing a sleeping room in the hotel annex with a 30 pct oxygen atmosphere; and working out a more economical means of supporting slusher drifts. These are a few of the projects now on tap.

Substantial Savings in Rock Drilling

Prior to 1954, two classes of rock drills were used at Climax, 3½-in. drifters and 3⅛-in. stopers. The leyner drills used 1¼-in. steel for regular drilling and 1-in. round for coupled longhole steel. In almost every instance, 2⅛-in. Carset bits were used on the drifters. For the stoper drills, 1-in. quarter octagon steel and 1¾-in. Carset bits were standard.

With the opening of operations on the Storke level, the mine and planning departments felt that lighter machines, smaller bits, and smaller steel could be employed to advantage. A testing program was initiated on this basis and the results substantiated preliminary ideas. But testing and proving a rock drill is one thing, to get the miner to accept it, still another. The lighter machines finally selected were the 90-lb Gardner-Denver RB94 stoper, 100-lb Ingersoll-Rand 38A, and LeRoi-Cleveland H-10 jackhammer and pneumatic leg combination. These drills use ⅞-in. hexagonal steel with 4¼-in. collared shank and 1½-in. Copco-Pacific bits. With this equipment substantial savings have been realized in initial cost, bits, steel, compressed air, powder, and time. On the Storke level, these lighter drills are used exclusively for drift and stope work and they are finding increased application on the Phillipson level.

Test Stope Accelerates Program

A drift on the grizzly level of the mine was set aside to serve as a test area for drilling equipment. One man can drill 400 to 500 ft per shift and this setup permits rapid testing of materials without interference or delays that would normally occur if the experimental work were involved with production mining.

Testing in the special drift can be carried out under uniform conditions and inferior materials and equipment can be eliminated prior to testing by the miners. After being tested in the drift the machines or materials are then taken to the mine and operated under mine conditions for a final proof.

The test drift was recently used to develop a new bit and coupling for longhole drilling. The change was from 2⅛ to 2-in. bits and from 1 13/16 to 1 11/16-in. couplings with change in bit skirt design to permit one type of thread for all connections. Repeated contacts with manufacturers and constant testing in the drift evolved a satisfactory coupling and a choice of three bit designs. Testing with the miners narrowed the bit choice to one and gave favorable coupling results. A large quantity of bits and couplings are now on operational tests with the miners, and if these results bear out former tests, recommendations will be made for acceptance.

Underground concrete is an item of considerable expense to the mine dept. and the target of 6000 yd per month is large by any standards. Because of expense and time involved in use of concrete, an effort has been made to use prefabricated steel forms in every possible application. With this line of thinking, planning has worked with the mine in developing a jumbo and steel forms for forming loading

cutouts. This jumbo will replace wood and promises a saving of 65 pct in forming costs. With large targets and identical drift sections, the initial cost of this type of equipment can be rapidly absorbed in savings. The jumbo and forms are, in principle, the same as those used in lining tunnels. They have been modified in design to fit the conditions that exist in the Climax mine.

New Temporary Drift Support

In the past two months, this department and the mine dept. have made significant progress in developing a new method of temporarily supporting slusher drifts where previously 8x8-in. square sets or wedge-and-slot type roof bolts with landing mat were used. There were three considerations in developing the new method of support: 1) The miners driving the drift should be able to do their own roof bolting with the machines used to drive heading. 2) The support required is temporary, since the slusher drifts are concreted soon after they are driven. 3) The support must save time and money over the method in use.

To meet the first condition, the manufacturer was requested to furnish left-hand thread, expansion-shield type roof bolts to fit the left-hand rotation in drill machines. To tighten the shields in the holes a wrench was made of a 1⅛-in. square socket welded to a 4-ft piece of ⅞ hex x 3¼-in. shanked steel. The 3¼-in. shank prevented the hammer from striking the steel, so only the rotation of the machine was effective. By the addition of this simple wrench the miner can install the roof bolts with the equipment used to drive the drift.

Seventeen of the bolts were installed and tested for pull-out. It was determined that the lightweight machines, telescopic jacklegs, and light stopers could develop from 125 to 150 ft-lb of torque on the bolts, and the minimum pull-out on ¾-in. bolts was 12 tons. Several of the bolts pulled apart at a 17-ton load without moving the anchors. This satisfied the second requirement.

Installation of new temporary drift support using standard drilling equipment. Man operating drill is tightening an expansion-shield type roof bolt with special attachment.

The third consideration could be determined only by trial installation in a drift. However, the expected cost was reduced by substituting a No. 9 by 2-in. chain fabric for the landing mat, which had been standard. Besides a saving in initial cost this fabric has proved more versatile than the mat, due to its flexibility and ease of handling. An initial cost comparison on the three methods of support, based on actual installation, shows the new method to be 35 pct cheaper than timber and 30 pct cheaper than wedge-type bolts and landing mat.

Testing and cost comparisons are not complete on this work; however, if the results continue to be so favorable, its use will be extended to other locations where temporary support is required prior to concreting.

Attacking Crushing and Milling Problems

Planning also assists both the milling and crushing departments in solving prevalent metal wear problems. This phase of activity has a two-fold func-

Typical Surface Construction Completed Since 1950

No. 3 and 4 mills. Building and six complete mill units with all required facilities
No. 1 crushing plant, including new coarse ore bin
Central heating plant, steam distribution, and heat units
No. 2 crushing plant, miscellaneous equipment, remodeling, and machinery installation
Ten apartment buildings with 18 four-room units each
Molybdenum concentrate storage warehouse and empty barrel storage warehouse
Hotel modernization
Interior painting of No. 3 mill, No. 4 mill, mine repair shop, and other buildings
Installation of television facilities
Aggregate plant enlargement and bulk cement facilities
Modernization of hotel rooms, hotel kitchen, and dining room
Remodeling of old mine change room
Phillipson level dispatcher's office
Addition to regrind plant
Million gal tank addition for mill water
Enclosed ice skating and hockey rink
Hospital enlargement and remodeling
Storke level crusher including building, conveyor, ore bins, and all accessories
Construction of new dormitory, new mill office, enlargement of general office, recreation hall, transportation change room
Construction of 70 new houses (3-bedroom units)
Community shopping center
Drying plant addition including hearth-type dryer with oil-fired units
Construction of 175-ft thickener and pumphouse
Community dial system office for Mountain States Telephone & Telegraph Co.
No. 3 and 4 mills, Storke level, compressor building, and mine substations
White level compressor building
Addition to mill water supply to meet 10,000 gpm demand
Railroad installation—Storke level and No. 3 and No. 4 mill railroad spurs

Three of the new 18-unit apartment houses for resident employes. Overhead is a portion of the 4000-ft conveyor belt from the Storke crusher to the fine ore bin. This is typical of the construction jobs completed in the last five years.

tion: it assists the operating departments as well as aiding the sales dept. staff in testing new materials as they are recommended.

Climax ore presents a severe wear problem in grinding. Annual records of wear life of various materials have been kept by the operating departments and these records are being expanded and the data used in conjunction with various new materials that are being tested. Specific wear problems are hard to duplicate in a laboratory, and materials are therefore being tested in actual service under standard operating conditions. The function of the planning dept. is to correlate and supervise the testing program and to supply the results of the program to the interested parties.

Wear is a problem in all phases of crushing and grinding. Testing programs are either planned or have been completed on jaw crusher plates, chute liner materials, screen rods, cone crusher lines, ball mill liners, scoop lips, grinding balls, and classifier wear shoes.

Every man in the department understands fully that cooperation with the other Climax departments is of utmost importance, and that his principal duty is to aid the operating departments in every way possible. An engineer in this department soon finds that his work does not encompass routine and standard jobs.

It is difficult to measure the value of any service department. Many of the Climax projects are for long-range planning, but the target is to show, each year, a saving which is several times the departmental operating costs.

New Construction

As an example of some of the work done outside of the mine and mill, the department has provided plans and estimates to revise the four-story main warehouse from wooden floor and bin construction to all-steel, fire-proof construction. The warehouse has self-supported concrete first and third floors, and conventional construction would call for steel bins on all floors with the wooden second and fourth floors replaced with steel and concrete construction. In place of this, a plan was submitted that proved 40 pct cheaper and satisfied all warehousing needs. The design called for 14-ft high steel bins with angle supports attached to the bins at the 7-ft level. The angles on the bins will support a second floor made up of steel grating. In this way the grating can be prefabricated and the second floor merely laid in place after the bins are erected. This department selected the bins and grating to be used and drew up the necessary plans and estimates. When the installation is started it will furnish the required engineering supervision.

Auxiliary Departments

Widespread Use of Synchronous Motors Gives High Power Factor

ELECTRIC power is the main source of energy for mining, crushing, milling, conveying, and processing ore at Climax. Power purchased from the Public Service Co. of Colorado is delivered over two transmission lines at 115,000 v to the Climax substation, where six 3333-kva single-phase transformers step it down to 13,800 v. From this main substation power is distributed through two main circuits to strategically located substations. Intermediate transformers have 440-v secondaries going to the switch and control centers at various points of utilization.

U. F. Toucher
Chief Electrical Engineer

Underground Power

A 4/0 3-conductor steel wire armored cable rated at 23,000 v brings power to the underground operations. The cable is installed in the Storke level ventilation raise and terminates at a 3-pole air-break transfer switch. One side of the transfer switch is connected through an oil circuit-breaker to the Storke level substation. The other side of the transfer switch is connected through an oil circuit-breaker to the Phillipson level system, with a 4/0 3-conductor steel armored cable installed in the borehole from the Storke level to the Phillipson level switching station. Power is distributed from the switching station to three underground substations located as near the load centers as physical conditions permit.

Underground power at 440 v is distributed by 350 M cir mils cable from manually operated circuit-breakers. Total connected load underground is 27,500 hp with a calculated load factor from 30 to 40 pct. All circuits are adequately protected through coordinated tripping schemes.

Direct current power is provided at 275 v for the haulage system. The motor generator units all have flat characteristics and are paralleled by the use of automatic reclosing tie breakers, and the dc system is adequately protected by sectionalizing breakers. Main haulage trolley wire is 6/0 figure eight, supplemented by 500 M cir mils feeders, while laterals utilize 4/0 trolley wire and the return circuit consists of bonded trackage with a supplementary 500 M cir mils feeder. There are 44 traction units for the operation, ranging from 1½-ton trammers to 20-ton main line units.

Compressed air, supplied by a central surface compressor station located above the town, provides all requirements for both Phillipson and Storke levels. The five units that compose the compressor station—three 800-hp, one 600-hp, and one 500-hp—are driven by line start synchronous motors supplied by a 4000-kw substation.

Surface Plants

Crusher and mill sections represent a load of 22,745 hp with 1220 motors, ranging from 1 to 600 hp, utilized in the various beneficiation processes.

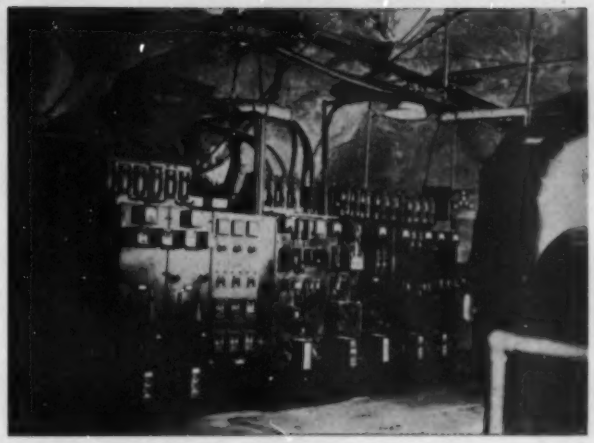
Crushers are supplied with power by a 3000-kw substation. Crusher control components are housed in a building remote from the crusher structures and push-button stations are located in the building for remote control of the starters for the operating units. Intricate interlocking between conveyor belts and crusher units, resistance-sensitive electronic relays, and power tripping relays eliminate ore pile-ups and crusher overloading. Liberal use of synchronous motors on the Symons cone crushers helps to maintain a 96 pct power factor.

The Storke gyratory crusher, one of the largest in the world, is driven by a 500-hp wound-rotor induction motor. The crusher motor control circuit is interlocked with the oil pressure system so that in case of oil pressure failure the motor will be de-energized at a predetermined time. The pan-feeder and impact belt are driven by dc variable speed drives to prevent overloading of the belt transporting the ore to the coarse ore bin. The crushing and conveying system is interlocked with a tramp iron detector.

The secondary crushing circuit consists of a pan-feeder at the coarse ore bin, conveyor belt feeding the Symons crusher, and conveyor belts to the mills. The entire system is interlocked to prevent ore piling in case of belt stoppage. The conveyor belt drives range from 125 to 350 hp.

The nine ball mill units in the No. 1 and 2 mill sections are equipped with 450-hp synchronous motor drives. Each mill and flotation unit has its own control center with power supplied by two 3000-kw substations. The main oil circuit breakers are in two separate buildings remote from the mill structure, and circuits are brought into the mill units in underground conduit.

Mills No. 3 and 4 have six 600-hp wound-rotor induction motor drives. Each unit composed of a ball mill, flotation unit, classifier, pumps, and other auxiliary equipment is served by a separate 1000-kw substation and is provided with the latest in control centers.



Underground switching station that supplies power to electrical equipment is shown on the Phillipson level.

The substation for the regrind plant has a capacity of 3000 kw. The main plant drives consist of seven 200-hp synchronous motors. In addition there are flotation cell, pump and classifier drives, and control centers in this plant similar to those in mills No. 1 and 2. Power is also supplied to two 125-ft thickeners and a new 175-ft thickener.

Water Supply

Water supply for ore processing and tailings disposal and domestic use presents a major problem. Since the Climax operations are situated on the Continental Divide and watershed is limited, reclamation and conservation of water are of great concern.

Mill water is pumped 4 miles from Robinson Lake by three 700-hp motor-driven pumps of 3000 gpm capacity each and one 250-hp pump rated at 1000 gpm. Pumping station power is supplied by a 2000-kw substation. Motors are started across the line and capacitors connected across the motor leads prevent low voltage dips. Surge suppressors and hydraulically operated values protect the system against heavy surges and pump reversal in case of power failure.

Supplying Power and TV Signals for the Townsite

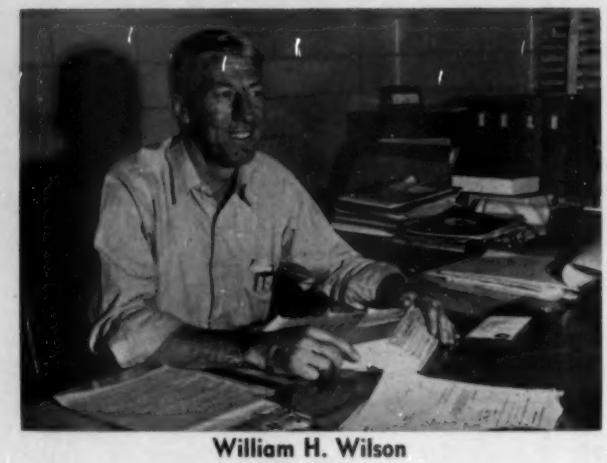
The more than 500 dwelling units in the townsite are supplied by three substations, two of 300-kw capacity each, and one with 500-kw capacity. Power is distributed throughout the townsite at 440 v and stepped down to 110/220 v for domestic use. The majority of the dwellings are equipped with electric ranges and the hotel uses electric power for all cooking, baking, and refrigeration.

One of the unique features is the community TV system provided by the Climax Molybdenum Co. as a community service to its resident employes. A total of 555 outlets have been installed to serve the permanent residents of Climax.

Antennas and head-end equipment of the broad band type for simultaneous reception of four Denver channels are installed on McNamee Peak at 13,803-ft elevation. Signals are brought from the antenna to the townsite over 12,000 ft of K14 coaxial cable with four amplifiers to maintain signal strength at normal levels. More than 50,000 ft of RG11U coaxial cable is installed in the townsite area to provide the circuitry to the dwelling outlets. Amplifiers and automatic level controls at strategic points compensate for circuit attenuation and provide each outlet with 1000 μv signal strength.

Financial Control

Financial And Product Control



William H. Wilson
Controller

ADMINISTRATION required for financial security and for good product regulation, shipment, and inventory is vested in a controller's dept. under direct jurisdiction of the resident manager of the Climax operation, or, in some instances, the corporation's treasurer in New York. This department is responsible for the correct accumulation and reporting of all costs and capital investment of the western organization and for periodic statements of total production of concentrate, shipments, and remaining inventories of such concentrate.

To accomplish the degree of accuracy necessary to meet nationally accepted accounting practices requires a well established and coordinated procedures manual, which has been installed. This manual serves the following departmental units under the controller's direction: accounting, budgeting, purchasing, warehousing, and metallurgical records.

Financial records of the Climax Molybdenum Co. are centralized in the New York office. The western organization constitutes the major cost portion of the corporate earnings statement. Other items quite as important as the production expenditures are handled, of course, which enter the balance sheet accounts, although the volume of these items is considerably smaller than the expense classifications.

Elements of the Climax cost account classifications are as follows: operating payroll; maintenance payroll; operating supplies; maintenance supplies; operating power; maintenance power; other expenditures; maintenance, other expenditures.

Labor

A general ledger control account records the total liability for all local labor distributed to all accounts for a monthly accounting period. A series of offsets are recorded against this account to spread labor costs to the appropriate functions. A daily labor distribution is made of all employes working for daily wages. Many Climax employes work on different account classifications each day and this daily labor distribution helps assure a faster monthly reconciliation and also helps eliminate a peak load at month end.

Warehouse Inventory Carefully Controlled

All supplies, material, and equipment are obtained through a standard purchase order procedure and inventoried on a first in-first out basis. Authorized personnel of the operating dept. issue a requisition to the warehouse where the order is filled from the storehouse inventory. The warehouse replenishes its inventory by issuing a requisition to the purchasing dept. All purchase requisitions are authorized by the resident manager. The purchasing dept. asks for four bids from suppliers handling the respective items. A purchase order is issued to the successful bidder. Material or supplies ordered are shipped to Climax in care of the warehouse dept. Invoices and freight bills are directed to the purchasing dept., where quoted prices, extension of calculations, and terms of purchase are checked. Approved invoices are forwarded to the disbursement section of the accounting office.

The accounting section is responsible for correlating the quantity specified on the invoice with the quantity indicated on the receiving tally issued by the warehouse dept. Upon verification of receipt of materials and supplies, a duplicate copy of the invoice is routed to the warehouse for proper recording of material on stock ledger cards. A warehouse charge-out slip releases inventory material to the operating departments. This charge-out slip gives the department the quantity, names of the items, stock classification code numbers, unit prices of items, and the total charge made for items. Charge-out slips are processed daily and forwarded to the cost accounting section of the accounting dept. A monthly reconciliation is made between the storehouse inventory account and the total of the stock ledger cards. A physical inventory is in process at all times on some part of the warehouse stocks. Correlation of the physical inventory to the written stock cards and the stock card reconciliation to general ledger assures proper reflection of inventory assets at all times.

All electric power consumed at the Climax mine is purchased from Public Service Co. of Colorado. Both Climax and Public Service have totalizing meters to verify kilowatt-hour consumption for any given period of time. Watthour meters located throughout the plant give power consumption for use in the cost accounting program.

Other expenditures required for services of consultants, rentals, telephone charges, divisional office light bills, and medical attention for occupational injuries are presented to the disbursement section of the accounting office for auditing purposes and account classification before being presented to the controller's office for final authorization for payment.

Production and capital asset expenditures are planned in detail for an entire year. The budget dept. aids the operating departments in accumulat-

ing cost data and cost applications for anticipated production. These forecasts of planning and costs are compared with the accomplishments and expenditures of the actual operation. Sufficient planning and engineering studies prior to application of needed improvements are very valuable as an overall financial control of an active mining company.

Controls on Concentrate Product Are Rigid

Procedure for measuring concentrates produced each month must be carefully outlined in order to establish accurate and correlated quantities. The methods of weighing must have internal checks and balances, and such information must be computed by another department entirely independent from the operating departments. Weightometers are used to record total tonnage processed by the mine. Ore haulage train records are established to determine a car factor which can easily verify the weightometer records. Small weightometers are placed upon the separate ball mill units to determine the amount of feed entering the concentrating plant. Samples are taken not only of the final product but also throughout the various phases of concentration. Figures from recording scales used in the concentrate packing dept. are submitted to the metallurgical bookkeeping dept. for processing. A complete set of concentrate production, shipments, and inventories is furnished daily to all concerned. The cost accounting dept. is in a position to compute unit costs of production of any of the concentrates for any period of production. The concentrate product control procedure is exacting and must be rigidly enforced. Molybdenum stocks are valued by the last-in first-out method.

Control over capital expenditures is accomplished by a method that calls for the establishment of the amounts for the desired capital items after proper engineering review. A project number is then assigned and the funds are formally requested to be voted by the board of directors. The form requesting funds must contain adequate explanation of the need or economy of the proposed capital expenditure. If warranted, the board of directors appropriates the funds requested and the form is enclosed. Thereafter all expenditures in connection with this project are charged thereto until completion. On those occasions when it appears that the project cost will exceed the estimate an additional request for funds is made with reasons given for the overrun.

Appropriate detailed property records are maintained for all capital installations.

The entire success of this mining enterprise depends upon the ability to control the financial expenditures necessary to produce, store, and ship concentrates at the lowest possible price.

Financial Control

Purchasing Dept.

PURCHASING for Climax Western Operations is handled through the Denver office. The function of a purchasing dept. has been defined as *purchasing the right materials at the right time in the right quantities and at the right price.* However, the present-day purchasing dept. is charged with a much wider scope of responsibility than just the procurement of materials and service. Purchasing has a definite part in public relations.

Much of the company's contact with other concerns or individual suppliers is made through this department. The reception sales representatives encounter, the time and consideration given their products and service, and the manner in which a transaction may be consummated all go to formulate the esteem held by others for the company.

Within Denver and the general area are many mine and mill supply houses, as well as machinery and equipment manufacturing concerns. In addition, most of the national suppliers' representatives have offices in Denver. Through this immediate contact with personnel the purchasing dept. procures supplies more efficiently and is given the opportunity to sell the company by following a code of ethics that is equitable to all concerned.

Understanding of Market Conditions Provides Better Quality

The quality of materials or commodities must be maintained. Substitutions are not understood to mean an inferior quality, but a better product at the same price, or an equal product at a lower price. However, a lower quality of product may in some cases perform the same particular need satisfactorily. These factors are determined by close contact between the purchasing dept. and management, research, planning, and operations.

J. E. Russell

Purchasing Director

The purchasing dept. must be conversant with current market conditions as well as the possibility of a change in trends due to seasonal operations, labor, supply, and demand. Through vendor contact and trade publications, information can be obtained as to availability of materials, lead time necessary to insure delivery when required, and market conditions pricewise so that orders can be placed at a time most advantageous to the company. This information, as developed, is passed on to the operating and warehousing departments.

Another function of the purchasing dept. is to be constantly alert to new or improved products or methods which are called to the attention of the planning or operating departments. Frequent visits to the mine by purchasing dept. personnel creates an understanding that results in better teamwork for the good of the operation.

When an order is ready for placement all the necessary information has been developed and made a part of the order, that is, the mode of delivery, delivery date required, terms, and f.o.b. point. All items carry full and proper description and are unit

priced. Orders are placed on a competitive basis.

A continuous flow of material and supplies must be received at Climax to insure a smooth and uninterrupted operation. The expeditor works constantly with the suppliers to see that shipments are made as promised. In many cases it is then necessary to continue the tracing with the carrier to effect delivery.

Detailed records are kept on all transactions. Orders when completed are filed alphabetically by firms, together with all information pertinent to that individual order. A copy of each order is filed numerically and also by commodity. This provides a quick reference for future purchases as well as historic record. Drawings of standard and special equipment are filed for reference in reordering or in supplying repair items. A complete catalog file of all suppliers is maintained as well as registers of manufacturers. An up-to-date price file is maintained of all standard lines of shelf goods.

Financial Control

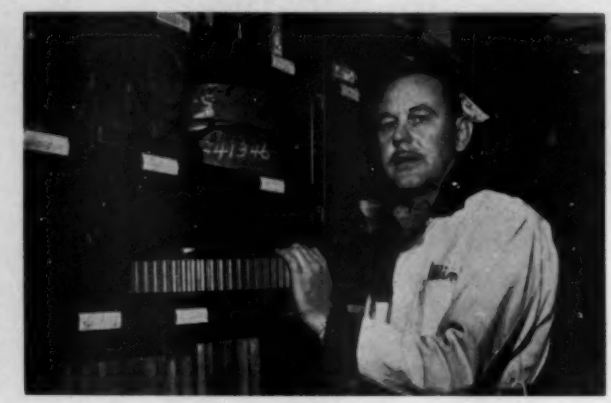
Supply

THE supply dept. at Climax is one of the largest of its kind in the mining field. The general warehousing program consists of requisitioning, receiving, stocking, issuing, and shipping necessary supplies, materials, and equipment. As much of the inventoried materials as possible is kept under cover in warehouses, but in many instances it is found necessary to store materials on docks in open areas. All this material, whether on outside docks or in storage warehouses, is stored in accordance with its proper classification and is so identified. Identification carried on the material is also carried forward to the card record system.

A catalog compiled and distributed every six months records any changes in classification or nomenclature of materials on hand for issue. Due to the large volume of receipts and issues handled daily, a catalog starts becoming obsolete almost immediately after coming off the press.

A modern Cardineer system has been introduced in the supply dept. to facilitate handling and accounting for materials. It is estimated that about 20,000 items are carried at all times in the stores inventory, and it is felt that through the streamlined operation of the Cardineer, a more accurate and efficient handling and accounting method is effected.

Most of the general stock items required for the operation of the entire industrial establishment at Climax are stored in the large building in the center of the picture. Stocks of larger materials are kept on outside storage docks.



Marshall Flint

Superintendent of Supplies

Materials are divided among 37 different classifications and are grouped, coded, and stocked. All nomenclatures are checked to conform exactly with manufacturing references and are so carried on the stock records. The material, inventorywise, turns over four times each year or once every three months, with the exception of those items carried for insurance purposes. All stock record cards are added once each month and balanced in relationship with the overall monthly inventory report. An adding machine tape is kept on each class for auditing purposes. At least twice each year the stores inventory is counted and a reconciliation is made between the physical and card count.

Salvage Program Creates Savings

A salvage program has been introduced wherein all repossessed materials, including scrap and other metals, are classified and disposed of. A continuous surveillance is made of the overall property, and salvage materials are reclaimed and brought to the salvage section. Materials considered to be of further use are classified, stocked, and issued much in the same manner as new material described above. Accumulated amounts of scrap and metals are sold. A large saving is effected by issuing usable materials from the salvage yard to the operating departments rather than issuing new materials from the stores inventory.

A constant survey is made of all obsolete and surplus materials. These materials, while actually kept in stores inventory until such time as they are disposed of, are cataloged, checked by the department head, advertised and sold by the purchasing dept. Every effort is made to keep the stores inventories at a working minimum and to eliminate all obsolete materials as quickly as possible.

Accounting Dept.

THE accounting dept. handles all expenditures and distribution of costs for the Climax operation. Control of accountability is headed by the chief accountant and the assistant chief accountant working through supervisors of the following sections: cost accounting, IBM, payroll, accounts payable and receivable, invoices (warehouse supplies), and typing section and PBX operators.

The cost accounting breakdown for labor, supplies, power, etc., is further broken down by operation and maintenance functions. The accountability could be said to fall in the following categories:

1) **Direct Charges:** These charges go directly into the respective account.

2) **Allocated Charges:** The complexity of some accounts forbids a direct charge to either program. Therefore costs are accumulated into an account and then prorated, by various bases, to the regular ore grade and low grade programs.

3) **Reserve Charges:** Accounts are set up to handle large maintenance charges, monthly charges being determined by historical records and past performance on the life of conveyor belts, ball mill liners, rock drilling machines, slusher motors, etc.

Major Account Divisions

Mining
Milling and Crushing
Byproducts Plant
General, Administrative, or Overhead Accounts
Mine Distributive or Mine Service Centers
Mill Distributive or Mill Service Centers
Special Accounts or Service Departments
New Products Research
Production Process Improvement
New Venture Investigation
Mining Claim Development
Capital—New Construction and Equipment Cost Accounting

Account Classifications for Two Divisions*

Mining

Preparation — New Development
Development costs are also kept on each new working place.
Handling — Slusher system and Grizzly system.
Ventilation — Movement of clean air in the mine.
Haulage — Motor Haulage and Maintenance of Way.
General Mine Expense — Overhead Accounts.
Mine Distributive — Special accounts allocated to the other five accounts.

Crushing and Milling

Crushing — Primary and Secondary Breaking.
Primary Concentration — Feeding and Grinding, Classification, Flotation.
Cleaner Plant — Regrinding, Classification, Flotation.
Filtering and Drying.
Packing, Loading, Shipping, and Storing.
Tailing Disposal.
General Mill Expense — Overhead Accounts.
Mill Distributive — Service accounts allocated into the above accounts.

* The other account classifications follow the same general pattern.

A. K. Hanes
Chief Accountant

At year-end an adjustment is made to conform to actual expenditure.

It is the responsibility of the cost dept. to record properly all expenditures for labor, supplies, power, and revenue in their respective accounts for the purpose of determining the cost of the regular grade and low grade programs on the Phillipson level and the regular grade program on the Storke level.

Payroll

It is the responsibility of the payroll dept. to control various Government reports, employe benefits, and payroll deductions.

Payroll deductions create a problem, as they average 28 per month in addition to Federal and State withholding taxes and social security. As Climax is an outlying community, many items normally handled by the individual are allowed to come through the payrolls: glasses and refraction for glasses, telephone bills, Leadville Hospital building fund, store bills, payments into the employes' credit union, and donations for national drives. Since Climax is a company-owned town, there are payroll assessments for rent, lights, coal, and LP gas, for those employes living in Climax. The company also contributes liberally to employe benefits such as group insurance, pension plan, and Blue Cross.

IBM Div.

Machine accounting was introduced at Climax in November 1953 to provide faster handling of payrolls and labor distribution. When an employe first goes to work, the IBM dept. makes up a master payroll card including such information as the employe's name, seniority date, division (mine, mill, etc.), department or crew within the division, badge number, employe number, tax class, sex, social security number, marital status, veteran or nonveteran status, job code, job description, hourly pay rate, and birth date.

Daily time cards are prepunched and interpreted by selecting information necessary for the Climax operation from the master payroll card.

Since the installation of the IBM dept. to handle payrolls and labor distribution, Climax has added various cost analysis reports that were uneconomical to handle and prepare. The future goal on the IBM's is to handle stock ledger cards of storehouse inventory, supply distribution, and property records. IBM machine accounting is a definite asset to Climax and will become more so in the future.

Budget Dept.

Paul J. Ducharme

Director of the Budget Dept.

THE adoption of budgeting has brought many advantages to the Climax operation. The detailed planning required in making a budget demands close cooperation between departments. Thus the operating units of the company are welded together through a better understanding of mutual problems. The budget as a proposed plan for future operation is stated in terms of tons of ore to be mined, pounds of product to be recovered, and dollars of cost. It is prepared at Climax during the last quarter of each year. The budget spans a five-year period. Cost is estimated in monthly detail for each account classification for the first year of the period. The budget for the last four years of the five-year period is prepared only in summary form for general classifications.

Budgeting is a staff function designed to aid the operating departments in meeting their announced targets in production and cost. The budget is a yardstick used to measure performance in various functions. It is not a weapon to exact performance from operating departments. Constant review of actual operating results and comparisons with the budget allow operating personnel at Climax to know the position of their departments at all times and to take whatever steps may be warranted to bring operating figures in line with estimates or to revise the estimate.

Sales Forecast Key to Budget

The first step in preparing the budget is a five-year sales forecast for molybdenum, tungsten, tin, and pyrite. The sales forecast originates in the New York office. The tonnage and grade of ore required to fill the demands of the sales forecast are then determined by the engineering dept. at Climax. A detailed mining schedule for the first year of the period is made showing the amount of ore to be drawn from each area of the mine for each month of the year. Yearly mining schedules are made for the remaining four years of the budget period. The operating departments review the schedules to determine the feasibility of the plans.

Preparation and development schedules are also prepared by the Climax engineering dept. The schedules are based in large measure upon the sales forecast demands as outlined in the budget. Preparation and development involve long-range forecasting. A time lag of approximately two years exists between the initiation of development work in an area and the production of ore from the area.

After production and preparation requirements have been determined each operating department is advised of the targets. Acting as a consultant the department head, aided by the budget dept., then determines the cost budget for his department. Each operating group determines its own budget and assumes full responsibility for meeting its goals.

Cost estimates for the budget are based on the actual cost experience of prior years, modified to reflect foreseeable events of the future. Methods and materials improvements as well as changes in labor rates and materials prices are considered when cost estimates are made. After each department has estimated the cost of its operations, the budget dept. consolidates the estimates into a budget for Western Operations. The completed budget for Western Operations is then sent to the budget officer in New York for consolidation with the operating budgets of other phases to provide an overall budget for the company and to predict cash income and expenditures, profit and loss statements, and balance sheet positions.

Budget Controls

Each month detailed comparisons are made between actual cost and budget cost for each account. The causes of variances are determined and reviewed with the responsible department heads. Particular attention is given to those variances that are likely to reoccur. The cost implications of a plan of action may be discussed with a department head if the need arises. After meeting with the various department heads, the budget director writes a report to management. The report is reviewed by the department heads before it is submitted to management.

Capital Budget

The capital budget is based upon requirements of the five-year sales forecast and the proposed projects that have been submitted to management by the operating departments. A careful review is made of all proposals to determine the rate of return the proposals are likely to earn. Western management then screens the proposals to choose those which are to be sent to the New York office for approval by the general management and the board of directors.

After a capital project has been undertaken, actual cost of the project is carefully compared with the estimated cost. Wherever possible the projected rate of return is compared with actual rate of return on investment. In this way management acquires a sound basis for evaluating future capital proposals.

The advantages of improved planning are the greatest contribution of the budget to the Climax operation. Another advantage is an increased concern with cost among operating personnel. Better planning and cost consciousness are helping to make Climax a more efficient operation.

Human Relations

Public Relations at Climax

ABOVE—Recently completed gatehouse at the Climax mine and townsite. The new structure houses the public relations dept. and provides some facilities for the protection dept. LEFT—New one-stop shopping service has done much for the convenience of resident employes and families. Groceries, clothing, restaurant, and garage service are only a few of the items available here.

BUSINESS today navigates in a sea of public opinion. The degree to which each individual company concerns itself with the public varies, and indeed the mining industry because of its relative isolation has been permitted to escape considerations of a public relations nature longer than most segments of American business. But each day new problems arise that demonstrate the importance of an enlightened public, fully familiar with the functions and objectives of resource industries as a vital segment of the American economy. Growing recognition of this need for *emphatic understanding*, or feeling of oneness with mining, has established public relations as a new staff function in the industry.

Recognizing the Need

For Climax, this recognition took place in 1952 at the time the operating organization was being expanded to accommodate an enlarged production establishment. Many samplings of opinion suggested that recognition and appreciation of Climax could be vastly improved.

To effect such improvement three organizational changes were made: 1) a public relations dept. was established at Climax under the direction of Gordon Weller; 2) the former personnel dept. was reorganized with increased staff and responsibilities to function as an industrial relations dept.; and 3) a community management dept. was created to handle housing, recreational programs, and plant protection.

Physical and Communication Facilities Were Improved

As a series of foundation stones to make Climax a better place in which to work and live, the inadequacies of Climax community physical facilities were relieved by an extensive construction program covering housing, school, health, shopping, and recreational facilities.

Employe communications were improved in several respects. The employe newspaper, the *Moly Mountain News*, was converted from monthly publication to biweekly and restyled with increased photo and art budgets. A twice weekly bulletin known as the *HiGrade* was distributed through "Take-One" boxes located throughout the operation. This bulletin carries up-to-the-minute news and activity announcements.

For these publications and for other requirements such as business forms and safety manuals the Climax Press was established. To compensate for poor

RIGHT—Recreation hall at Climax is complete with gymnasium, bowling alleys, rifle range, and TV room. New structure attached to recreation hall is the commissary with soda fountain and notions counter.

Photo display located in corner of the exhibition room of the new gatehouse. Gordon Weller, public relations director (left) and Don Stephens (right) are preparing the displays.

radio reception and comparative isolation, the community television system was installed as described in the article on community management.

In addition to the establishment of the standard press-radio-TV relations program, steps were taken by the public relations dept. to make better friends of the Colorado general public. The following programs were instituted:

Pictorial Brochure: A 12-page pictorial brochure in color was prepared describing the Climax operation and emphasizing its improved community facilities. Seventeen thousand copies of this booklet were distributed to leaders throughout the state. Copies made available to the sales dept. of the company proved valuable as a sales tool for industrial customers of molybdenum, and a second printing was made for distribution by sales representatives in the U. S., Canada, England, and the Continent.

Tour Program: A carefully planned invitational tour program was developed for the purpose of bringing leaders from all over the state to Climax in groups of not more than 35 men per tour. Invitees were selected with the assistance of local leaders in each community with an effort to bring one community representative for each 1000 population in small communities, and one for each 2000 population in larger cities.* In addition to the invitational program, tour accommodations were extended to appropriate organized groups requesting the privilege of a visit to Climax.

Sunday Supplement: Certain large segments of the public with which Climax is concerned could not be reached by the invitational tour. These segments included the public beyond the Colorado border, particularly those in the mining industry, and the people in metropolitan Denver who knew the "old" Climax and who were accordingly necessary audiences of the re-education campaign. Another medium was needed—one which was penetrating and widely broadcast in the Rocky Mountain region.

An unexpected and generous proposal from the *Denver Post* to feature Climax in a special supplement of the Sunday color-gravure "Empire Magazine" was a welcome solution to the problem. *Post* feature writer and columnist Robert W. (Red) Fenwick spent several weeks at Climax in covering the story. Industrial artist Otto Kuhler was commissioned to do several water colors for the edition. Orin Seeley, recipient of many national press photography awards, did the camera work.

Speakers Program: In response to the invitational tour program and "Empire Magazine" publication, many requests were made for Climax officials to speak throughout Colorado. In Denver, the principal company officers delivered talks before such groups as the Chamber of Commerce with very beneficial press response. Talks given in smaller communities by other company management representatives brought corresponding results.

* This formula could not be applied to metropolitan Denver where population was too large and other means of communication were available.

Employe picks up copy of *Hi-Grade*, a community news bulletin published twice weekly for up-to-the-minute notices and news of camp activities.

Follow-Up Programs

Two additional programs have been added to the public relations operation at Climax:

Scholarship Program: This program was instituted early in 1954. The College Entrance Examination Board, in a forthcoming handbook, describes the program as follows:

> The Climax Molybdenum Co. awards two scholarships annually in connection with its operations at Climax, Colo. One scholarship is awarded to the son or daughter of an employe of the Climax, Colo., operations and one to a son or daughter of a nonemploye living in Lake, Eagle, or Summit County, Colo. The scholarships provide four years' education at any university in the U. S. of the student's choice leading to a bachelor's degree. Tuition and normal fees are covered, plus $500 per year stipend for the scholar. Selections are made from students in the upper third of high school graduating classes on the basis of high school scholastic records, College Entrance Examination Board test results, activities and community records, and personal interviews by the Climax Scholarship Committee. This committee is composed of three prominent Coloradans who are not employes of the Climax Molybdenum Co. Climax scholars may select any field of study of their choice. Scholarship renewals are made automatically for scholars in the upper third of their college class.

New Visitors' Reception Center: As a part of the modernization of the Climax property entrance, a visitors' reception center has been built with office facilities for public relations, plant protection, and employment. A display room has been provided to accommodate the casual visitor's interest, and motion pictures may be shown to groups in a space provided for that purpose.

These programs conducted by the public relations dept. at Climax have resulted in material improvement in the morale of the community and in the general understanding of the Climax operation in the West.

Industrial Relations Activities

Russell Miller and Ernest Jones

Assistant Director and Acting Director of Industrial Relations

PRODUCTION efficiency is generally obtainable only from a satisfied, happy work force. Provision of such a force is the responsibility of the department of industrial relations. The department as it exists today is the result of some 25 years of continuously adapting and modifying personnel functions to meet a large variety of changing conditions and needs. During this period production fluctuated between a few hundred tons and more than 28,000 tpd and the number of employes increased irregularly from fewer than 100 to 1450. While labor turnover is now well under the industry average, over the years it has varied from 2 to 25 pct per month. For the first 13 years of this time, the employes were not represented by a union. Then, in succession, they became affiliated with a national union, disaffiliated with this union, became an independent union, and finally reaffiliated with another national union.

Each of these factors resulted in many problems that became a part of the industrial relations dept. responsibilities, necessitating an increase in its personnel and activities. Twenty-five years ago the activities that were considered industrial relations in nature were handled on a part-time basis by the chief accountant, a doctor, the general superintendent, and his assistant. At the present time the department consists of 33 employes and is now directly responsible for all problems of employment, safety, training, hospital, clinic, and labor relations.

The director of the department has the same standing in the company organization as the superintendent of an operating department. The department functions on the principle of providing necessary services for the union, the employes, members of management, and the company. In so far as possible, decisions and recommendations are based on facts and are wholly impartial. It is only by strictly adhering to this policy of impartiality that the department has been able to operate effectively.

Most of the matters in which the union is involved are handled either by the director or the assistant director of the industrial relations dept. This includes such items as regular grievance meetings, arbitrations of grievances, and contract negotiations, as provided in the formal labor agreement. It has been found that informal discussions with union officials have eliminated a number of potential grievances and have been an important factor in minimizing the number of grievances processed.

Written grievances are tabulated by department, supervisor involved, and subject matter. In this way it is possible to pin point sources of difficulty and consider possible solutions. A summary of 1954 grievances revealed that 48 pct of the total griev-

Climax Community Expansion

1. New housing: 70 three-bedroom houses and ten apartment buildings with 180 four-room apartments
2. Hotel annex, accommodating 68 men, guest and banquet facilities
3. Combination gymnasium and auditorium for the school, seating 800 people for basketball games, or 1200 for stage performances
4. Additions made to school and hospital
5. Shopping center, built for lease operation, providing a wide variety of supplies and services
6. Steam plant to satisfy a portion of the domestic as well as industrial heating requirements
7. Reception building to accomodate both business and casual visitors
8. Youth center and indoor skating rink to supplement facilities at the recreation hall, ball park, and ski tow.

ances received could be classified under three headings. Fourteen pct of them dealt with the subject of qualifications, an additional 14 pct involved unsatisfactory work, and 20 pct arose over the assignment of work.

Climax production employes first organized in 1944 and are now affiliated with the AFL. Of recent years labor agreements have been effective for two years with a wage reopening clause after one year's time. The regular company negotiating committee consists of the resident manager, the general superintendent, assistant general superintendent, various department superintendents, and the director and assistant director of the industrial relations dept. Neither union nor company attorneys are members of the bargaining committees, although occasionally in the past an attorney has been called in for advice of a legal nature.

Employment

The employment div. is responsible for maintaining an adequate working force of general payroll employes. In addition, it is also largely responsible for obtaining properly qualified hourly rated and salaried staff employes for a variety of positions.

Every applicant for employment is carefully screened and detailed information concerning each is recorded. A list of the more important physical requirements and a pamphlet containing pertinent information about the community and operations at Climax are also given him for consideration. Every effort is made to give applicants a complete and unbiased picture of working and living conditions at Climax, so that once the applicant is accepted for employment he will understand what is required of him and will obtain maximum job satisfaction.

Manpower budgets are set by top management for each department and the employment div. takes whatever measures are necessary to maintain the proper number of employes in all departments. Complete records are kept and a copy of each employe's work record is kept in the department where he works.

Sources of applicants for employment depend upon local and national conditions. In the past, advertising, recruitment trips to various parts of the country, and the facilities of the Colorado State Employment Service have been used to obtain new men. On occasion, employes have been encouraged to suggest to their friends and relatives that employment is available at Climax. Recruitment trips are made to various technical schools each year to interest graduating seniors in mining and related fields to consider permanent employment at Climax. In addition, from 40 to 70 technical students are hired during the summer months. At the conclusion of the summer each student is evaluated to determine whether he should be offered future employment. This gives the various supervisors an opportunity to select those who appear to be desirable for future employment and also gives these employes a chance to decide whether they are interested in working for Climax again. For many years the company has followed a policy of providing summer employment, in so far as may be practical, for employe's sons who are at least 17 years old. While sons would not be offered a job the second summer unless their work had been satisfactory, very few instances are found where they have not been re-employed.

Each employe goes through a carefully planned introduction procedure. After an applicant is accepted and passes the physical examination, he returns to the employment office where he completes the personnel forms and has the opportunity of signing up for the pension plan, Blue Cross and Blue Shield, the Employe Benefit Plan, and savings bonds. He receives his work number and then proceeds to the safety dept. for a brief summary of the company's safety policy and is issued necessary safety equipment. From the safety dept. he proceeds to the protection dept. for a security check. His fingerprints and picture are also taken at this time and he is issued an identification badge. If he wishes to apply for housing, he is taken to the housing dept. for a discussion.

When the new employe reports for work, his supervisor shows him around and introduces him to his fellow workers. At this time the supervisor discusses with him methods and regulations pertaining to his particular job. About ten days later an employe of the safety dept. meets with the new employe to stress safety and the need to follow general and specific safety rules. Shortly after this a follow-up interview by the supervisor is designed to make the new man feel at home and to help him overcome any possible difficulty. Every effort is made to see that the employe knows how he is doing and to help him wherever needed.

While the screening and introduction procedures may appear long and time-consuming, it is believed that they have contributed to a marked reduction in labor turnover. In 1954 the labor turnover for the general payroll employes was 41 pct. This is a record low since 1949 and is below the industry average.

All terminating employes are given an exit interview. The purpose of this interview is to discover the real reason for the termination and to learn from the employe what complaints he may have regarding working and living conditions. As each group of 50 exit interviews is completed, they are summarized and tabulated. Copies of the summary containing the results of these interviews are given to such people as department heads, hotel management, and the management of the community store. Considerable interest has been shown in these results, which have been helpful in determining sources of dissatisfaction.

Hospital Program

Climax has a modern, well equipped hospital and clinic designed to serve the medical needs of its 2500 residents. The facilities of the hospital are not limited to employes who live in Climax but are available to all employes of the company and their families, many of whom live outside Climax.

Although primarily intended to provide emergency treatment and care for industrial illness and injury, the doctors and hospital staff also take care of nonoccupational cases that involve the employe and his family, excluding obstetrical and major surgical cases. Climax families include more than 600 children from kindergarten through high school age, plus a number of children of preschool age.

The hospital is at present staffed by two doctors, two laboratory technicians, a chief nurse, six registered nurses, three nurses' aides, and two service employes. During 1954 the building was expanded and modernized to provide a spacious waiting room, a combination business and receptionist office, new offices for both doctors, new examining rooms, an emergency driveway and receiving corridor, and an oxygen storage room.

A considerable amount of new equipment was

purchased and installed during the past year. Major items in this category include equipment for the X-ray and surgery room, explosion-proof lighting fixtures, emergency lighting equipment, diathermy machine, portable hydraulic shock table, new autoclave, and oxygen therapy equipment. The kitchen was re-equipped with new furniture, a new refrigerator unit, an ice-making machine, and a combination automatic dishwashing machine and sink. Two portable television receivers were purchased and donated to the hospital by the Climax Community Council for the benefit of inpatients.

More than 1100 patients per month visit the hospital, of whom approximately 65 pct are employes and 35 pct employes' dependents. The monthly inpatient load is near 45 and averages 171 hospital patient days per month, or four hospital days per patient. About 140 physical examinations are given each month. These examinations are partially repeat physicals that are carried out on a 12 to 18-month cycle depending on the doctors' work load.

Employes living in Climax are charged $1.50 per month for hospital service and those living outside Climax pay $1.25 per month. This entitles the employe to care and treatment for nonoccupational illnesses at the hospital or in the home. Dependents pay a nominal fee of $2.00 per call for treatment at the hospital. The pharmacy carries a well rounded supply of drugs and biological products which are dispensed without additional charge.

The monthly fee paid by the employes falls far short of meeting actual hospital expenses and the company makes up the substantial deficit. The services of the hospital and clinic contribute much toward a high standard of community health. Since employe morale is closely related to the health level of the family unit, the company feels this additional expense is justified.

Human Relations

Safety Dept.

SAFE working conditions and practices are prime factors in efficient production and worker satisfaction. The major duty of the Climax safety dept. is to prevent accidents of all kinds and thereby open the way for the most efficient production possible under the most favorable working conditions reasonably attainable. Every effort must be made to lower the frequency of accidents and reduce the need for personnel to the point where it handles compensation, issuing and fitting of eye-protection devices, and a minor amount of statistics.

Organized in 1933, the safety dept. at Climax has expanded until it is now made up of a safety engineer, five underground safety inspectors, fire chief and assistant fire chief who also act as surface safety inspectors, a full-time industrial hygiene technician, a secretary, and a record clerk. Of the seven safety inspectors, five are on a permanent basis and two are supervisors from the mine dept. Every mine supervisor spends three to six months as safety inspector before he moves up in mine management.

Underground Safety Inspection

The senior underground safety inspector works on day shift and in addition to regular inspection work fulfills these responsibilities: 1) Talks to all new men that are being transferred from the cleanup crew to their first production crew and thoroughly covers the general safety rules and the specific job safety rules of the crew to which they are being assigned. 2) Assigns shifts and working places to be inspected by the other inspectors. 3) Attends the foremen's meeting every morning on the Storke level. 4) Makes up schedule of safety meetings for the coming month in the mine dept. 5) Attends every mine safety meeting on day shift. 6) Makes routine inspections of the condition of safety dept. physical equipment in the mine. 7) Inspects each man hoist twice every month.

Thomas Hoy

Safety Engineer

Climax Safety Record

1939 - 1953

Average National Metal Mines Frequency	= 28.39
Average Climax Plant Frequency	= 16.80
Average National Metal Mines Severity	= 6.88
Average Climax Plant Severity	= 4.34

1926 - 1954

58,014 tons of ore mined and milled per lost-time accident.

1,611,620 tons of ore mined and milled per fatality.

This period of time allows a supervisor to become acquainted with the whole operation and provides an opportunity to become thoroughly acquainted with safety policy and practice.

The safety inspectors work with the supervisors in a constant search for hazards and in training men in the safe way of doing their tasks. The new men, of course, need the training, and the experienced men sometimes develop a sense of false security. In the course of their routine inspections, all first-aid and stretcher boxes are checked and kept filled with supplies.

The two surface safety inspectors are in charge of all fire equipment and fire fighting on the property. In the course of checking fire equipment in

the surface installations, they conduct safety inspections.

The industrial hygiene technician samples the air for dust content at routine stations on various parts of the property and conducts occupational surveys and counts the samples in a small laboratory. Samples are collected with a Midget Impinger and counted on a Spencer Bright-Line cell.

In addition to air sampling, the industrial hygiene technician is charged with investigating problems of industrial health and the sanitation of industrial areas, controlling the purity of domestic water supply and the fumes from molten metals and welding, and directing the safe handling and storage of corrosive chemicals.

Every accident is recorded and the information gained distributed to the supervisors in a unique and comprehensive manner. Statistical sheets tabulate all injuries, frequency and severity, and afford comparison with other parts of the plant by separating the plant into 21 operating groups. A supervisor can compare the accident experience of his group with other groups doing similar work. In addition to the statistical sheets, each accident is tabulated according to division and supervisor. A bar graph posted in the mine lobby shows each supervisor how his crew is doing as compared to other crews doing like work and crews working in the mine dept. doing unlike work. After the supervisor has checked these three places—statistical sheet, accident tabulation sheet, and the bar graph—he can readily tell who on his crew is out of line safety-wise and start on corrective methods before something serious happens.

U. S. Bureau of Mines first-aid courses are offered about six times a year and participation is entirely voluntary. An annual safety award is granted to everyone who works 85 pct of the available working shifts without a disabling injury. Safety meetings are conducted once a month on every crew in the surface dept. In 1955 the efforts of management and the safety dept. have been directed toward impressing upon the supervisors that they are, to a considerable degree, responsible for injuries on their crews. Private agencies and every agency of the State and Federal Government are used as much as possible to assist in reducing accidents. These include the State Compensation Insurance Fund, Insurance Inspectors, State Metal Mine Inspector, USBM, and the National Safety Council.

Human Relations

Community Management

Carl DeTemple
Community Manager

WHAT are the weather conditions at Climax? How does a person obtain a place to live? What about police and fire protection? Where is the nearest school? Is there a church? How far is the shopping district? What do employes and their families do for recreation? These and many other questions are asked every day by visitors and newcomers to Climax. The answers to these recurring questions probably best illustrate what living in Climax is actually like.

What Are the Weather Conditions at Climax?

The weather at Climax is exactly what might be expected on the Continental Divide at an elevation of 11,320 ft. Snow is plentiful and winters are long and severe. Temperatures vary from 30° below

Living accommodations are equally important for both single and married employes at Climax. Completed in 1954, the new Hotel Annex provides living facilities for 68 men as well as guest and banquet rooms.

zero to a maximum 79°. In spite of the heavy snowfall, averaging 18 ft annually, the streets in the community are kept clear by company snow removal equipment and highways to Denver and nearby towns are open all year.

How Does a Person Obtain a Place to Live?

For the unmarried man, housing is no problem. The recently remodeled hotel and new hotel annex have 193 single and double furnished rooms available to single employes. Those facilities are operated by the L & H Service Co., a private contractor, and a nominal charge of $3.00 a day is made for board and room.

The company maintains 507 dwelling units in the Climax townsite for married employes and their families. However, there is such a demand for company housing that there is a wait of 14 to 24 months, depending upon the accommodation desired. A point system is utilized in awarding each unit. Points are accumulated on seniority, application date, rate of pay, and number of dependents. Units vary in size from furnished two-room efficiency apartments to unfurnished three-bedroom bungalows. Included in the 507 housing units are 180 two-bedroom apartments. Rental rates are extremely reasonable. To protect both the tenant and the company, each unit is inspected periodically to eliminate unsafe practices and conditions.

What about Police and Fire Protection?

Since the entire community of Climax is located on company property, a protective force is maintained to safeguard the lives and property of employes. The protection dept. is also charged with the responsibility of protecting the industrial areas from fire, theft, and sabotage.

A well trained volunteer fire dept., equipped with the most modern fire-fighting devices available, is always on call. This department is trained to be anywhere on the property, fighting a fire, within a period of 5 min after the alarm has been sounded. Very few communities can boast of more efficient and complete fire and police protection.

Where Is the Nearest School?

The Max Schott public school is centrally located in the townsite of Climax. The school is accredited by the Colorado State Board of Education and is staffed with 32 teachers. Student enrollment is now 640. A complete education program is offered by the school from kindergarten through the 12th grade. A well rounded extracurricular program is also available to every pupil. This program includes student council, dramatics, public speaking, journalism, music, and sports. Skiing and basketball highlight the extracurricular sports activity.

An important recent addition to the school is the hot lunch program. Approximately 300 pupils are now served hot meals daily.

Is There a Church?

Four different religious denominations hold worship services regularly in Climax. Varied religious programs are available to residents, including Sunday schools, Bible study, and Christian Endeavor.

What about Shopping Facilities?

Climax residents have a modern shopping center located across the highway from the main entrance to the community. Housed under one roof are a restaurant, beauty and barber shops, supermarket for groceries and meats, general store with departments for furniture, appliances, sporting goods, apparel for men, women, and children, and a complete service station. This establishment, covering 21,000 sq ft of floor space, is one of the most modern and complete one-stop shopping centers in the region.

Section of the Climax community of 507 dwelling units. This is a portion of the most recently constructed homes, making a total of 70 individual houses built since 1950.

What Do Employes and Their Families Do for Recreation?

Probably more enjoyment is derived from the unique television system provided by the company than from any other phase of the recreation program. The Climax community television system is the world's highest, with receiving antennas located on the top of Mt. McNamee, 13,803 ft above sea level. Signals are received directly from Denver transmitting stations, some 60 air miles away. At no expense to the employe, coaxial cable leads from the mountain peak to every residence in the community including the recreation hall and the hotel annex, providing some 555 outlets.

The recreational hall, which is open to all employes and their families, has the following facilities: library, reading room, television room, billiard and pool room, six bowling lanes, pistol and rifle range, and gymnasium. In addition to regularly scheduled sporting events, the gymnasium is used for such activities as children's parties, bingo games, and dances. Recently released movies are also shown three nights a week in the gymnasium.

A lighted baseball park provides many hours of pleasure during the summer season for both spectators and players. The Climax winter sports area is equipped with a 2470-ft ski tow operated by the Continental Ski Club, an employe organization. For ice skating enthusiasts, there is a 100x200-ft enclosed skating rink. The company has also provided a youth center which includes an auditorium, a stage, and meeting rooms for teen-age and various youth organizations.

A community council, composed of representatives from different community organizations, has performed an outstanding job in promoting and supporting recreational and educational activities in Climax. Had it not been for the assistance of this organization some of the facilities mentioned here would not have been possible.

The company's continuing efforts to make Climax a better place to live in are paying dividends in greater satisfaction to all employes.

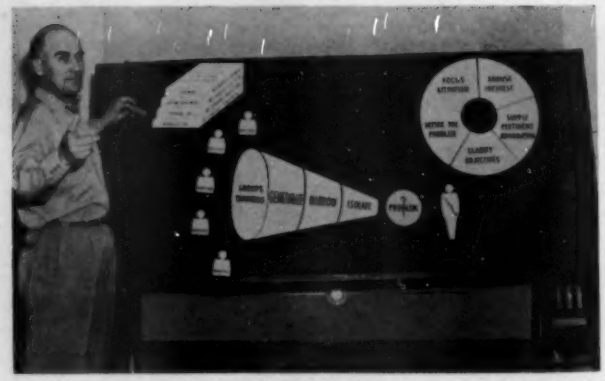
Training Program

THE supervisor is the real training man at Climax. This is true, of course, in many industries today. But at Climax the supervisor's importance as an instructor in the right methods of performing the jobs under his direction, his persistence in following through to see that work is done properly, and his ability to get men to follow his direction because they want to rather than because he wants them to—all these factors take on a keener importance in hard rock mining than in most heavy industries. The unavoidable dangers of mining, however, are so well known and identifiable that safety, efficiency, and production are inseparable.

This *work trinity* is the guiding principle toward which all planned training at Climax is directed. It is an old axiom that the right way of doing any job is the safe way or, conversely, that the safe way is the right way, ultimately resulting in greatest production. In the past this principle has not been easy to get over to the workman. Pressure for peak production has hit Climax recurrently through the years just as it has other mines. Present pressure to meet production goals as the result of Government stockpiling and increased industrial demand is reminiscent of war days. This sense of urgency occasionally tempts the individual workman to take shortcuts that prove costly in terms of production, injuries, or general confusion.

Supervisor Development

Realizing the importance of the supervisor, Climax has placed major emphasis on a supervisory development program. Since its creation two years ago, the objective of this program has been to make the operating supervisor a more efficient and effective leader and trainer of men. Management recognized from the outset that training was primarily a line responsibility rather than a staff function and that the main purpose of the training department should be to assist line executives and supervisors to fulfill their responsibilities in training subordinates. A building was set aside and equipped for training and safety meetings.



H. R. Moody

Training Manager

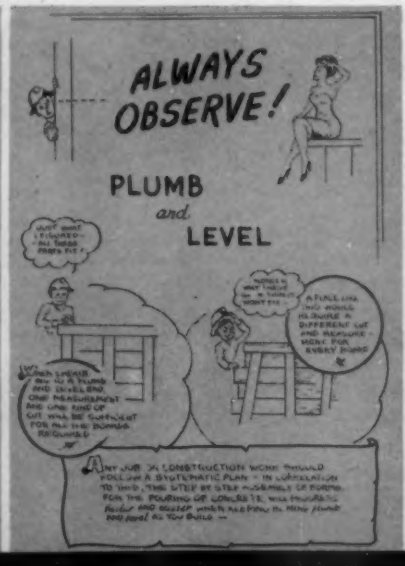
The basic training vehicle at Climax has been the conference method, which brings the full experience and considered thinking of operating officials to problems of training common to all supervisor personnel, namely, the need for 1) better understanding of the principles of leadership—of getting results through people, 2) greater skill in teaching the right methods of work, 3) increased ability to plan and simplify work methods, and 4) the consultative approach to operating and personnel problems as an effective and more frequently used management tool.

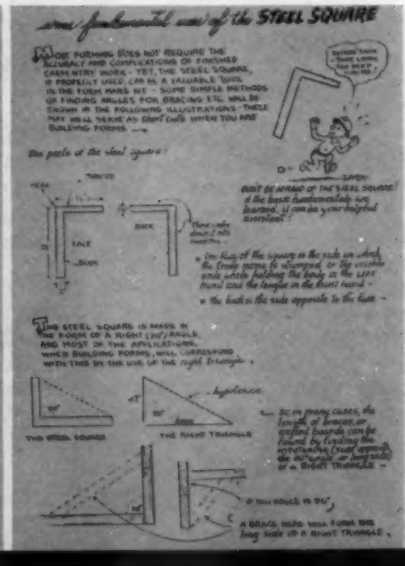
The supervisory development program has utilized the job relations, job methods, and job instructor training programs developed by the training within industry branch of the War Manpower Commission during World War II. These methods have since been widely used by industry and Government. The leadership program has also the *Man-to-Man on the Job* program of General Motors Corp.

The job instructor training has been given to some of the lead men as well as the supervisors in view of the fact that most of the job training is given by these key men rather than by the supervisor.

Conference leadership training has followed the pattern developed by the Du Pont Corp. in the smooth-functioning *discussion-leading* program. With the exception of orientation training given to employes new on a job and certain special courses which may introduce new equipment or work procedures, the fundamental basis of all Climax training is to develop the supervisor primarily through the conference method and then help clear the way for him to carry the training on down the line.

Three pages from a new training manual for the underground form-building crew. The booklet is pocket size and printed on washable and waterproof paper to stand mine service.





Looking west at the Outlaw and Calamity Mesa area from the Uncompahgre Swell. The La Sal Mountains of Utah are in the background. Orebodies in this district are a part of the Uravan mineral belt and lie about 60 miles southwest of Grand Junction.

Diversification

Climax Uranium Co.

Marvin L. Kay
Vice President and General Manager
Climax Uranium Co.

IN the spring of 1950, just two years after the inauguration of the domestic uranium program by the U. S. Atomic Energy Commission, the company entered the uranium mining and milling business through a newly formed subsidiary, Climax Uranium Co. This was the first venture into a new field of mining for Climax, which became the first old-time mining company, other than the vanadium producers, to become active in the embryo uranium industry.

Twenty-five years earlier, Arthur Bunker, president of Climax Molybdenum, organized and operated the U. S. Vanadium Co. at Rifle, Colo. With this background, he viewed the budding industry of the Colorado Plateau with much interest. Upon its formation, the new subsidiary entered into a contract with the U. S. Government and the potential uranium-vanadium properties of Minerals Engineering Co. were assigned to Climax Uranium Co. Funds for the construction of a processing plant and working capital were advanced by Climax Molybdenum Co. The old sugar mill building of the Holly Sugar Co. in Grand Junction was leased to house the extractive plant. Construction of facilities, which were based upon a new process developed for the treatment of both uranium and vanadium ores, was completed and the mill was placed in operation early in 1951. Subsequent to that time several alterations were made and the capacity of the plant increased. In terms of recoveries, the plant has proved to be one of the most efficient on the Colorado Plateau.

Recently the mill has been still further revised to increase capacity and simplify operations. A new crusher and sampling plant, completed this year, has been effective in streamlining ore purchasing and stockpiling, as well as providing feed for the mill. In addition, the percolation leach tanks for removal of the uranium from the slimes have been replaced with a modern continuous countercurrent leach plant.

Ores of the Colorado Plateau have been processed for many years, but uranium recovery is comparatively recent. Ores were first processed for radium and at one time the Plateau comprised the major world source of that element. After the African deposits were discovered the radium industry in the Plateau area could not compete economically. However, the vanadium content of the ores proved valuable and two companies built processing plants that for many years recovered only the vanadium. While it was known that the ores contained uranium, there was no commercial market for any quantity of uranium, and little or no effort was made to recover the now critical element.

When the Government inaugurated the Manhattan Project, it was imperative that large amounts of uranium be obtained quickly from all possible

Climax uranium processing plant at Grand Junction, Colo. New building under construction in the center and behind the thickeners is countercurrent leach plant to replace old percolation method. New crushing and sampling plant is in the lower right, with conveyor going to blending bins.

sources. The mills processing Plateau ores for vanadium quickly converted so that uranium could be recovered as well. When Climax Uranium Co. began its construction in 1950, it was the first time that a plant had been initially designed for the recovery of uranium and vanadium from Plateau ores and erected with funds supplied by private capital.

The industry at that time was relatively young and the extractive metallurgy of uranium was still in the formative stages. The Government and private industry were spending large sums of money for research but the demand for uranium was so great that it was decided to build a plant based on the best knowledge that was available at the time.

Processing Div.—
Vigorous Process Research Gives High Recovery

Climax Uranium's mill utilizes a sand-slime separation method applicable to the majority of uranium ores in the Colorado Plateau. The general flowsheet of the mill was selected after careful consideration of known methods of beneficiating uranium and vanadium ores. The process is flexible as to ores that can be handled. Its use of waste acids in the neutralization step permits treatment of 10 to 15 pct lime ores.

Through the desirable features of sand-slime method, the mill is able to discard about 60 to 70 pct of the ore with minimum treatment. Effort can then be centered on the high grade slime product with a reduction in cost and improvement in recovery.

Development of any process is usually based on fundamental data obtained from laboratory results, pilot plant operation, and from general experience in other plant operations. Normally in ore processing the fundamental data will include characteristics of the ore to be treated. In the Colorado Plateau where deposits are generally small and vary widely in basic composition, it is impossible to determine the characteristics of the feed ore. Climax treats ore from 50 to 75 different sources, and the same is true of most of the other processing plants. It is for this reason that most of the processing plants in the Colorado Plateau are in a more or less continual state of change in an attempt to keep up with changing conditions of mill feed.

Since the ores are usually sedimentary sandstones they are easy to grind. The values of both uranium and vanadium are cemented upon the sand grains and in grinding the ore, the cemented values are in a large part broken loose as an ultrafine slime. This property can be both beneficial and detrimental.

The neutralization section is an innovation introduced by the Climax Uranium Co. so that high lime ores may be handled. In the past high lime ores could not be processed in acid leach circuit for two main reasons:

1. Ores containing in excess of 4 to 6 pct calcium carbonate would, upon salt roasting, convert the vanadium into a water-insoluble calcium vanadate and vanadium recovery would be seriously affected.
2. Sulphuric acid used to leach the uranium would react with the calcium carbonate to form calcium sulphate, which in one form is plaster of Paris. The plaster of Paris would then set up in the now discarded leach tanks, stopping any percolation of the acid.

High Lime Ore No Problem with Ore Neutralization

In the Climax process, waste acids from the roaster gas scrubbers are used to neutralize the calcium carbonate contained in the ore. These waste acids are a mixture of hydrochloric and sulphuric acid. When calcium carbonate reacts with hydrochloric acid, it forms soluble calcium chloride that can be eliminated in the thickener overflow. The calcium carbonate that reacts with the sulphuric acid forms calcium sulphate which is quite insoluble in water and will, of course, be carried along with the ore. It has been found, however, that calcium sulphate upon roasting does not react with the vanadium to form calcium vanadate so that the conversion of the vanadium to water-soluble sodium vanadate occurs normally in the roaster. The calcium sulphate, also, is converted in the roaster to a dead-burned gypsum which does not set up. By use of this step, difficul-

ties generally encountered with high lime ores can be eliminated.

At Climax Uranium ore is received from the crushing and sampling dept. at −1 in. and ground in a 4x6-ft Marcy rod mill in closed circuit with an Akins classifier. Neutralization is carried out by pumping the slurry from the Akins classifier overflow to one of five 8x8-ft agitator tanks where it is mixed with the waste acids at 1.5 pH. The five agitator tanks are operated in series to provide sufficient contact time for the reaction between the lime and acid to occur. The overflow from the No. 5 acid agitator goes to another agitator tank where NH_4OH is added to bring the pH up to 6. This step is taken to precipitate any uranium or vanadium that may have been dissolved in the acid neutralization treatment.

Other benefits that are obtained besides the neutralization of the lime in the ore are:

1. Overall acid consumption in the plant is reduced; rather than add new acid, waste acids can be utilized.
2. Plant make-up liquors containing small amounts of uranium and vanadium are sent through the ore neutralization where the uranium and vanadium are precipitated and recovered in subsequent operation. This enables plant control of pregnant liquors at optimum levels for ease in refining.

Sand Slime Separation Simplifies Leaching

Another innovation in the Climax flowsheet is sand-slime separation. After the ore has gone through the neutralization step, it is pumped to a Dorr hydraulic sizer where a sand-slime separation is made. It has been found that by making this separation, 70 to 80 pct of the values contained in the ore can be concentrated into the slime fraction which will constitute about a third of the weight of the original ore. The separation is made at about 150 mesh.

The +150 mesh fraction from the sizer is sent to a Dorr rake classifier where it is dewatered to 75 pct solids. The solids are brought in contact with a dilute sulphuric acid solution in percolation leach tanks where the uranium and 15 to 20 pct of the vanadium remaining with the sands are leached out. This liquor goes to the uranium refining section. The leach tanks percolate rapidly and produce uniformly good tailings.

Slime Filtration Problems

Slimes in the Colorado Plateau ores, whether mixed with the sands or handled separately, constitute one of the most serious problems facing the processors today. The ores in general contain appreciable amounts of claylike materials that are extremely difficult to thicken and to filter.

Climax has installed two submerged roto-disk filters to overcome this difficulty. The overflow from the hydraulic sizer contains about 6 to 8 pct solids. This dilute slurry is pumped to the submerged filters to thicken the pulp to 40 pct solids, the overflow from which goes to conventional disk filters, where the pulp is further dewatered to 50 to 55 pct solids. The filtrate from the submerged filters is returned as make-up water to the rod mill.

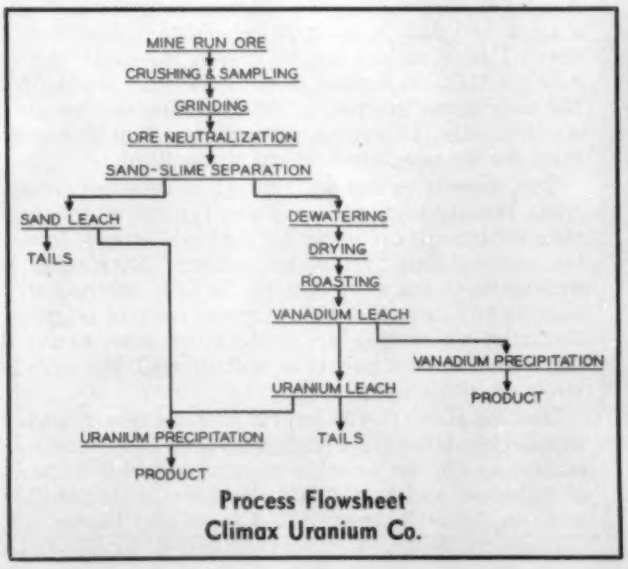
The submerged filters are so arranged that any of the sizer overflow that they cannot handle is sent to a 50-ft Dorr thickener where the material is thickened to about 20 pct solids. The underflow of the thickener is pumped to the disk filters for further dewatering.

It is felt that 1000 sq ft of filter area in the submerged filters will replace a 65-ft thickener. In fact they do a better job in that 20 to 25 pct solids is the maximum that can be obtained in the thickener underflow whereas the submerged filters can produce 40 to 45 pct solids. However, filters are more expensive to operate. Therefore, much experimental work has been done with various flocculating agents in an attempt to improve the thickening and filtering characteristics of the ores. Carboxymethyl cellulose gives the best results so far.

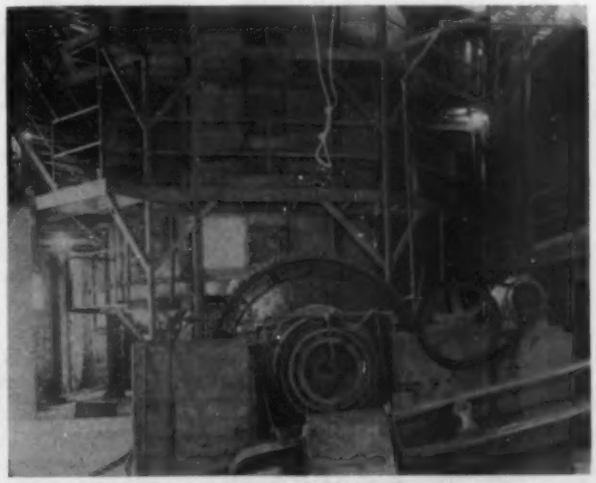
Thickener overflow is discharged into a series of settling ponds used as scavengers to guarantee against possible slime loss. Slimes carry a major portion of values, so losses at this stage are critical.

Salt Roast

Cake discharged from the disk filters goes in a screw conveyor to a salt mix agitator. Here the slimes are mixed wet with 12 to 15 pct by weight of salt. The salt is added to supply sodium ions which react with the vanadium in the ore upon roasting to form water-soluble sodium vanadate. After the salt addition, slimes are mixed in a pug mill with already dried slime diverted from the drier discharge in or-



Process Flowsheet
Climax Uranium Co.



Discharge level of the 10-hearth Skinner roaster in uranium treatment. Apparatus in foreground cools the calcine before leaching the vanadium with water.

der to lower moisture content to 25 pct before the mix goes to the roto-louvre drier.

The drier discharge is conveyed to a ten-hearth, 20-ft diam Skinner roaster where the ore is roasted for 2 hr at 825°C. Two major reactions occur in the roast:

1. The major part of the vanadium compounds are converted to water-soluble sodium vanadate. $V_2O_5 + 2\ NaCl + H_2O \rightarrow 2\ NaVO_3 + 2\ HCl\uparrow$

2. When the salt reacts with the vanadium and other constituents in the ore, it produces hydrochloric acid gas. This is recovered by passing the roaster gases through a scrubbing system and the acid thus made is used to neutralize the lime in the ore.

The calcine is discharged at 825°C from the roaster into a Baker cooler, which is a three-compartmented tube partially submerged in water. The calcine is cooled and discharged to a belt conveyor that delivers the calcine to the vanadium water leach.

The calcine is discharged into a small ball mill and ground with hot water. Very little grinding is done in this mill since only the particles larger than ¼ in. need be broken up. The slurry from the ball mill is discharged to a 6x6-ft agitator surge tank and then to a top-loading drum filter.

Leaching and Refining

The filtrate from the drum filter contains most of the water-soluble vanadium of the calcine. The cake is washed on the filter with hot water sprays and then is discharged to another agitator tank where it is repulped with hot water and is then filtered and washed on a second drum filter.

Solids from the second filter are pumped to thickeners for a final washing. The overflow is returned to the vanadium leach circuit, and the thickened pulp is sent to the new countercurrent uranium leach plant. In the leach plant, the uranium-bearing slime is mixed with sulphuric acid, then filtered on drum filters. This process is repeated four times under carefully controlled pulp densities and pH to produce maximum recovery of uranium in the ore.

The vanadium pregnant liquor from the drum filters is first clarified in pressure filters to remove any trace of sand that might have gone through the screens of the drum filters. The liquor is then pumped to a large agitator tank where it is heated to 90° to 95°C and sulphuric acid is added to bring the pH to 3.0. The vanadium will then precipitate as complex sodium polyvanadate $2Na_2O \cdot 7\ V_2O_5$, commonly known as red-cake. The precipitated liquor is placed in filter-bottom tanks where the red-cake is filtered, and the filtrate is sent to waste. The cake is thoroughly washed and is then charged into a fusion furnace where it is melted to form a dense black vanadium product.

The acid liquors from both the sand and slime leaching operations are sent to the uranium section where the uranium is removed and refined. Waste acid from this section containing residual acids and some vanadium is returned to the lime neutralization section.

Much effort, time, and money have been expended by the Climax Uranium Co. in its research activities. The processing of uranium is a relatively new field in the mining industry and while existing methods are fulfilling Government needs, the industry feels that many improvements can be made. The research dept. is conducting test work in its own laboratories as well as studying the results of the AEC research program. Many features that are being incorporated in the new mill recently completed in Grand Junction are the results of this research program. Until more is known of uranium processing, the research activities of the company must continue at a vigorous pace.

Captive Mining Properties Supply 50 pct of Climax Mill Feed

In the early days of the company, mining was more or less confined to the Outlaw and Calamity Mesa areas 50 to 60 miles southwest of Grand Junction. This is part of the Uravan mineral belt, a term applied to a narrow, elongated area in southwestern Colorado in which carnotite deposits in the Salt Wash member of the Morrison formation have a closer spacing, larger size, and higher grade than in many adjoining districts. The belt extends from Gateway, Colo., through Uravan to Slick Rock.

From 1936 to 1943 the main carnotite-producing region of southwestern Colorado and southeastern Utah yielded about 725,000 tons of carnotite ore, 87 pct of which was produced in the Uravan mineral belt. This area is still a major producer, but larger ore deposits are being found in other important districts.

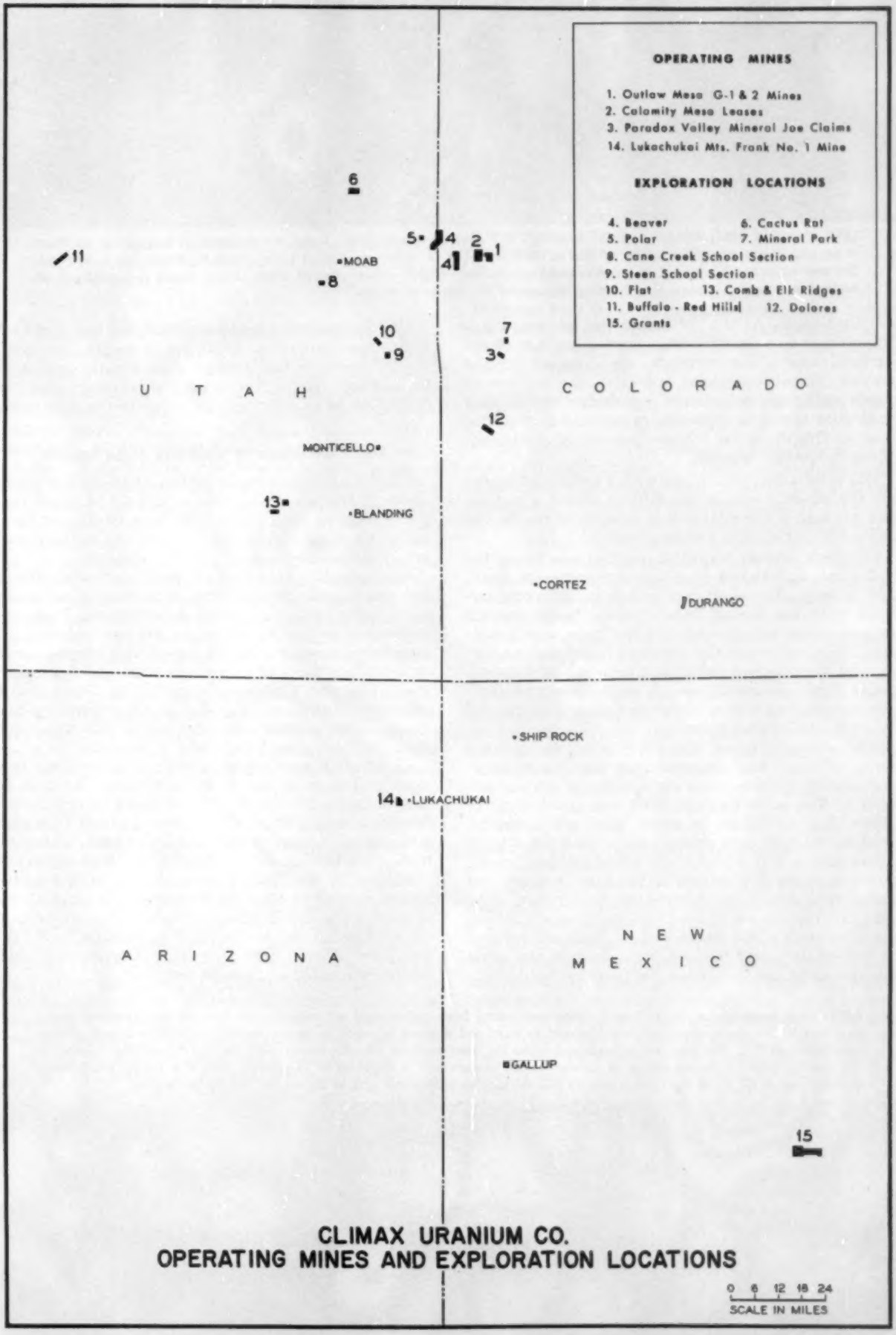
The mine production dept. operates the larger company properties on the Colorado Plateau. Two mines are on Outlaw Mesa, in the Salt Wash member. The two operations are a few miles apart and one camp houses personnel for both. Production is based on one shift per day for 12 days followed by a two-day shutdown. This isolated location of the camp makes this scheme the only logical method to permit employes to shop in Grand Junction.

The G-1 mine, oldest of the two Outlaw Mesa operations, is serviced by a 20° 7x8-ft incline about 300 ft long. Inclined entry is a common means of ingress to orebodies on the Plateau and, although not a hard and fast rule, it is generally assumed that about 1 ft of incline can be driven for every ton of 0.30 pct U_3O_8 ore in the ground. In other words, for 300 tons in the ground, a 300-ft incline can be sunk economically. Of course, extraction is usually higher than the tonnage blocked out by drilling.

The deposit mined at the G-1 is relatively massive. Mining methods used are typical of those in this section of Colorado in that the stopes follow the ore without system or pattern. Extraction is expensive this way, but it is the only method that assures any degree of recovery and control of grade. Actually, the stopes are little more than glorified drifts and when a pocket is encountered, the drift is widened into a room.

Drilling at the G-1 is largely with sinkers mounted on pneumatic legs. This type of drill has found extensive use in the uranium mining industry because of lightness and versatility. Broken ore is handled with an Allis-Chalmers HT-5 front-end loader and haulage is with a scrubber-equipped rubber-tired

Ed. Note: *Deposits in this area average about 0.25 pct U_3O_8 and 2.0 pct V_2O_5 with occurrence in irregular tabular orebodies, 2 to 4 ft in thickness. Individual lenses range from perhaps 200 ton size to many thousand tons. The ratio of U_3O_8 to V_2O_5 appears to be lower than for other Salt Wash deposits—1 : 5 or 10 as compared to 1 : 10 or 20.*



CLIMAX URANIUM CO.
OPERATING MINES AND EXPLORATION LOCATIONS

LEFT—Portal of 300-ft incline of Climax Uranium's G-1 mine on Outlaw Mesa. Dump and structures in background are those of an adjoining property not owned by Climax. MIDDLE—Top of incline slope at G-1 showing dump blocks for Granby car. Ore and waste can be dumped in separate areas as required. RIGHT—Diesel-powered 3-ton shuttle car in G-1 used for all haulage underground. Shown here dumping into car at the bottom of incline.

shuttle buggy. At the bottom of the incline, ore is transferred to a Granby-type car for haulage to the surface, where the contents are dumped on the ground. In this particular operation, the expense of constructing ore bins is not justified. Considerable quantities of waste rock are transported to the surface, so this dumping scheme permits easy disposal of the valueless material.

Ore is reloaded into trucks with a front-end loader for the 50-mile trip to the mill at Grand Junction. Ore haulage is sporadic and is dependent on the ore available rather than a time schedule.

Climax's newest operation on Outlaw Mesa, the G-2 mine, is serviced by a two-compartment shaft, 350 ft deep. The shaft has a cage in one compartment with the second 5x5-ft compartment serving as a manway and passage for the cage counterbalance. Electric power for the shaft hoist and underground slushers and lighting is supplied by a Caterpillar diesel-generator set. A diesel-powered compressor supplies the compressed air for drilling and other miscellaneous uses.

The orebody being exploited is made up of a series of small and discontinuous deposits at varying depths, thereby creating a difficult mining situation. The main haulage level was planned to be below the orebodies in order that ore could be slushed directly into mine cars. Small two-drum hoists and a 2-ft scraper are standard equipment. Ore and waste is trammed to the cage in small end dump cars which are hoisted to the surface. The cage and car system is used because it easily allows the separation of the ore and waste. Both are dumped on the ground, and the ore is handled in the same manner as at the G-1 mine, for haul to the mill.

Underground prospecting in both the G-1 and G-2 mines uses percussion drillholes in conjunction with Geiger counters and probes. The erratic nature of the ore zone makes this technique necessary and has proved to be of considerable value to the operators.

Small Orebodies of Calamity Mesa Leased

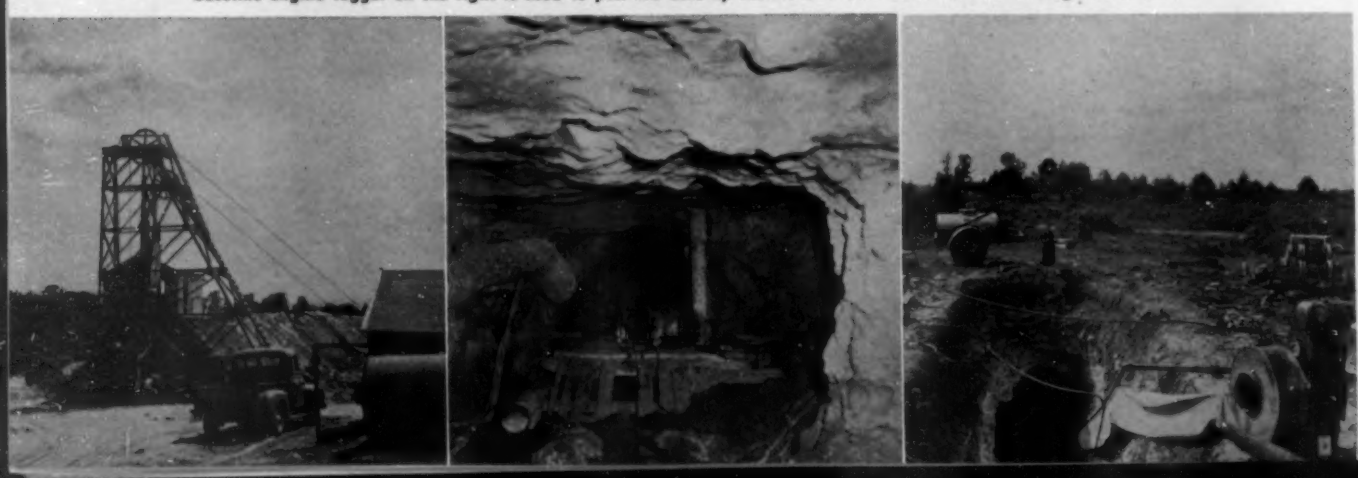
Climax's holdings on Calamity, located a few miles north of Outlaw Mesa, consist largely of small deposits ranging from 100 to 3000 tons. Orebodies generally lie about 40 to 125 ft from the surface and are exploited through 18° to 23° inclines.

Mining in this area does not lend itself to anything but small-scale exploitation, so a leasing arrangement is the normal means of development. The orebodies are delineated by wagon drilling and then an agreement is made with the lessee. The lessee is paid on a footage basis to sink the incline and necessary track, ties, and timber are supplied by Climax. All other equipment and supplies are furnished by the lessee. Climax purchases the ore at the mine and pays for the haulage to Grand Junction.

Exploration on Calamity Mesa is interesting because of the small size of the orebodies. An area is first drilled with widely spaced holes to determine favorable areas; then offset holes at closer intervals pinpoint the actual deposits. On occasions, orebodies have been missed with drillholes on 15-ft centers.

Mining in this area is reminiscent of the *gambusino* mining of Mexico. Frequently, a muck sheet is used to prevent dilution of the ore, and waste and ore are blasted separately. Light pneumatic leg drills, small portable compressor, and a rocker-bottom mine car are the usual equipment seen.

LEFT—Steel headframe at the G-2 mine. Mine cars hoisted from underground are taken to the level of the sheet-iron structure next to the shaft, where cars are trammed by hand and dumped to waste or in ore storage. MIDDLE—Typical slusher installation at G-2. The mine car is positioned under the hoist platform and the scraper fills the car through the opening in the planks. RIGHT—Lessees mining on Calamity Mesa operate with a minimum of equipment. This is a typical small lease. Gasoline engine tugger on the right is used to pull the cars up incline and acts as slusher for driving the incline.



Headframe at Mineral Joe in Paradox Valley. Ore stockpile is directly in front of the shaft and the waste dump is to the right of the ore bin.

Paradox Valley Mines Important Source of Ore

Farther south on the Uravan mineral belt, about 120 miles southwest of Grand Junction, Climax operates uranium holdings on the south rim of Paradox Valley. The Mineral Joe property on Monogram Hill produces from the Salt Wash member of the Morrison, as do the mines of Outlaw and Calamity mesas. Activities in this district started prior to 1920, but the early developments were primarily for the radium contained in the uranium and, later, vanadium. Before the discovery of the African radium mines, ore deposits in this area and to the north constituted an important source of radium. In 1920 it was reported that the Standard Chemical Co. was working three adits and that extensive orebodies had been found on Monogram Hill. However, activities today are much greater with Climax, U. S. Vanadium, and others producing the carnotite-bearing ores.

Climax's newest mine on the Mineral Joe claims is serviced by a two-compartment shaft, 220 ft deep. Indicated ore reserves at this location have made it possible to install a surface plant incorporating the features essential to efficient operation of a small mine. Availability of public power influences the degree of mechanization and electrification for Plateau operations. Unlike most, the Monogram Hill installations have access to power transmission lines and as a result are electrified throughout.

Underground mining methods are similar to those used at the G-2 mine, but the ore deposit permits better planning and more systematic stoping. Light drills, two-drum electric hoists, Mancha trammers, and end-dump mine cars make up the majority of the underground equipment. Ore is hoisted to the surface and dumped into bins at the headframe. In instances where the trucks are delayed in hauling the ore, facilities for stockpiling are available. The entire production is trucked to the Climax mill in Grand Junction.

A second property is operated on the Mineral Joe holdings by a lessor. This mine is exploited through an incline about 400 ft long. Mining is much the same as other Climax properties and no unusual methods are in use.

Climax Operation in Northern Arizona Ships Ore to Kerr-McGee Mill

The only company-operated mine selling to a custom mill is the Frank No. 1 mine in the Lukachukai Mountains of Arizona. This orebody lies in a concentration of uranium deposits about 50 miles due west of Shiprock, N. M. The richer and larger deposits, of which the Frank No. 1 is a part, are in an area of the Salt Wash sandstone about 3 miles wide and 5 miles long. The largest orebodies of the Lukachukai district are 90x350 ft and rarely exceed 4 ft in thickness.

As the operation is located on the Navajo Indian Reservation, Indian labor is used. The only mechanized feature of the mine is drilling, all production being hand-mucked and trammed. The main haulage line is equipped with burros. In spite of these primitive methods, the Indian workers are very productive, and the mine is definitely a paying producer.

Property Examination and Acquisition Is Important Function

Since the majority of ore deposits found on the Colorado Plateau are relatively small, companies, particularly those operating mills, must be constantly on the lookout for new supplies of uranium. A further complication of this obvious fact is the strong competition. Established mining companies, oil companies with mining departments, and newly formed mining companies are actively searching for uranium throughout the U. S. Some of these seekers are interested in making profits from mining operations and others are interested only in profits from financial operations.

Although competition is desirable, the present boom has made it difficult to purchase good uranium properties. Bidding has boosted prices and royalties to a point where the cost of purchase cannot possibly be recovered by mining, and mining companies must rely on their own initiative to find new or undeveloped locations.

Climax maintains an examination staff made up of geologists with 3 to 15 years' experience in the uranium fields. Some of these men have formerly supervised extensive projects and area exploration and are familiar with development and production methods. Properties examined by this group are generally brought to the attention of the company through owners or promoters interested in disposing of their undeveloped holdings. Personal contacts by management and field personnel also result in news of favorable areas. Of course a fair majority of these properties offered are eliminated in the office because they have already been examined, or the location is such that either exploration costs are prohibitive or the geology conditions are entirely unfavorable.

In spite of this extensive activity from the practical standpoint it is impossible to account for more than a fraction of the total effort extended by Government agencies, companies, and individuals in the search for uranium. To fulfill the company's aim to have a continuous ore supply for the Grand Junction mill, exploration efforts are centered in areas that appear to show promise from the geological standpoint.

Based upon the premise that a certain number of the properties brought to the attention of the com-

pany require on-the-ground examination, an exploration and engineering dept. is immediately available for this work.

Careful Exploration Is the Key to Economical Mining

Since early 1950 the company has operated four diamond drills and two wagon drills almost continuously, supplemented by outside drilling contracts for miscellaneous work in proving ore-bearing zones as well as delineating orebodies. This type of exploration is usually carried out in three stages, the first of which is a drilling program with holes 500 to 1000 ft apart to outline favorable zones. In the second stage this favorable area is drilled with holes spaced at 100 to 300 ft apart to search for the individual ore deposits. And in some cases, such as Calamity Mesa, a third stage of drilling is made with holes on 50 to 100-ft offsets from the discovery hole to outline the orebody.

Cost studies are maintained of all drilling projects. If after a moderate run of drilling the area shows lack of continuity, thickness, and grade, the project is usually abandoned before excessive sums are spent.

Drill core recovery as well as cuttings from the wagon drillholes are used as guides in the exploration projects. Some of the most valuable indications of favorable ore ground are the thickness and color of the ore sandstone, altered mudstone associated with the sandstone, and the presence of abundant carbonaceous material within the ore-bearing unit. An appraisal of these features expressed in numerical terms is made to evaluate the favorability of each hole drilled. When the values are obtained they are plotted on an isograd or favorability map. This map is invaluable in planning for drilling of the area.

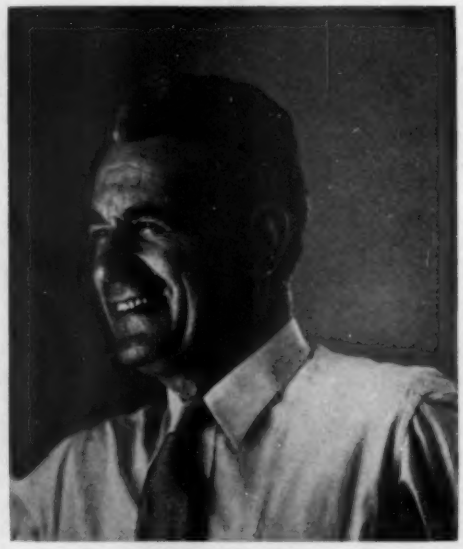
Financial Control

At the time the company was formed in 1950 the problem of establishing financial controls for a relatively new mining and milling field was vital. The need of self-education for both the accountant and the technical engineer in the economics of the industry was emphasized by the unknowns. With this in mind the accounting effort was directed towards the establishment of a system that would allow preparation of reports showing where each dollar was being spent and what it was producing. Financial reporting of the mining operations fell into two natural classifications — first, exploration and development of mineral deposits, and second, mining of the deposits.

Reports were designed to disclose the cost per ton of ore developed and mined, thus affording management with knowledge of each separate operation. In the processing div. close cooperation between technical knowledge of the process and the application of principles results in sound metallurgical data. With this information it is possible to establish reports that not only disclose expenditures, but also the unit cost of each pound of metal as it moves through the process. This gives the management an opportunity to analyze all conditions affecting the cost of production.

Diversification

Exploration Dept.



John J. Curzon

Manager of Exploration Dept.

THROUGHOUT the complexity of the mining industry—from original discovery of a deposit, through development and mining, and on to the ultimate processing and use of the product—one fundamental fact stands clear and unchanged, that mining by its very nature is based upon wasting assets or diminishing sources of supply. No orebody is inexhaustible. All mining properties must come to an end some day. Therefore, the continued existence of any mining organization must eventually depend directly upon the success of its exploration efforts.

Many once-famous organizations dropped into oblivion simply because no provision was made to perpetuate them through acquisition of new mining properties. On the other hand, a review of the companies that have maintained leadership over the years will invariably show that someone in each of these companies had the vision and forethought to acquire new ground. Sometimes this was made possible through the personal efforts of one individual, but more generally the extended life of a company is the direct result of an aggressive exploration policy.

The present position of the Climax Molybdenum Co. is such that its reserves of molybdenum ore are exceptionally large, which indicates that the Climax mine should be commercial operation for many years to come. This does not mean, however, that the company can become complacent and delay all thoughts of expansion and diversification. On the contrary, the company must plan for operating conditions far in the future. Furthermore, it feels that as one of the nation's leaders in mining, it has certain responsibilities, not only to its stockholders but to the general public as well, in helping to perpetuate the production of metals which have become so vital to everyday living and national safety.

Ores are not extracted from the earth and processed solely for the benefit of mining companies

Mineral exploration calls men to unexplored areas all over the world. The gargantuan appetite of industry has been the real creator of mobilized prospecting in new and old producing districts.

alone, but rather for the people as a whole. This fact is not always understood. Actually, the public is the ultimate consumer of metals, whether in everyday life or in the national defense effort. Mining companies simply form an important link in the chain of events extending from the original mining of the ore to the ultimate use of the product.

Geophysical Methods Are Important to Exploration

Within the memory and experience of many now alive, widespread changes have come in the science of drilling and blasting rock, methods of mining and rock support, transportation both underground and on the surface, and ore dressing and metallurgy. But changes of perhaps even greater importance to the mining industry have come in exploration, where tools are available today to probe for hidden orebodies beneath the surface that were undreamed of a few years ago. These modern tools can be grouped into two general classifications, geochemical and geophysical.

Under geochemical should be included the analysis of soils and stream waters, together with the analysis of plant life, which branches off into biochemistry. The USGS has done some very interesting work in developing geochemical methods which have now earned a definite place in the modern prospector's list of available tools.

Geophysics applied toward the search for minerals can be divided into several branches, which include magnetic, electrical, electromagnetic, gravitational, radioactivity, and seismic measurements plus the relatively little used sound reflection, temperature gradients, and micropalaeontology, although the latter has become increasingly important in the oil industry.

In addition to revealing the presence of hidden minerals, geophysics gives direct aid to the exploration engineer through such factors as the discovery of faults; detection of dikes resulting from igneous action; depth of a horizontal or sloping layer that gives way to one of greater or less density or electrical conductivity; and finding the relative locations of underground anticlines and synclines. By this added knowledge, many of the complexities of the earth's crust beneath the surface can be reconstructed in greater detail and accuracy than was formerly possible through the study of sections based upon what could actually be seen or penetrated by core drilling.

New Fields for the Exploration Engineer

Not very many years ago, exploration programs were generally based on such stand-bys as gold, silver, copper, lead, and zinc. More recently, intensive research throughout all branches of industry has resulted in the increased use of some metals and minerals and entirely new uses for others which were relatively unknown a few years ago, except to the scientists or mineral collectors. Metals like uranium, thorium, titanium, germanium, zirconium, and cerium, plus many others, would fall into this classification.

The need to find and produce valuable metals for the nation's ever-expanding production programs has opened up entirely new fields for the exploration engineer. As research continues and demand for new and rarer minerals increases, the scope of activity for the exploration engineer will broaden even further. All types of properties must be studied and evaluated. Basic conditions change through the passing years and mining properties that are commercial ventures today may not be so under different conditions in the future. Conversely, some properties that cannot be worked under today's conditions may in the future hold definite production possibilities. Included in the later classification are those properties for which there is insufficient demand for their product and those in which processing and metallurgical problems have not yet been solved. The last group is particularly intriguing as the development of a new metallurgical process or the solution of some particularly knotty problem in an old process may suddenly create conditions whereby a hitherto dim possibility will suddenly burst forth as a commercial venture of magnitude.

The Climax Molybdenum Co. plans to devote considerable effort toward developing new long-range mining ventures, either in the metallic or nonmetallic fields, which might prove to be commercial. Several types of mining properties are currently under consideration. Some involve the usual base metals or familiar precious metals; some have rarer metals with interesting metallurgical problems; others are in the nonmetallic field. Mining methods would range from standard underground systems of relative moderate tonnages to projects requiring large tonnages produced by either underground caving or surface stripping.

Each new project involves not only problems of ore reserves and production costs, but also varying factors of metallurgy and marketability of products. Consequently, when the merit of any mining venture is evaluated, very close cooperation must be maintained between the exploration dept., research dept., and market analysts, in order that all factors affecting each operation are given consideration.

Petroleum Activities

Gay V. Land

Manager of the Oil Dept.

DIVERSIFICATION has been an official policy of Climax Molybdenum Co. for several years and the intent of management has been to enter new fields potentially profitable enough to warrant expenditures of time, talent, and venture capital. Entry of Climax into the oil business dates from 1950. Although this department is one of the youngest in the company, its activities already extend over the oil areas of most of the U. S. and part of Canada. Activity is expanding as rapidly as profitable ventures can be found.

It was the intent of the company originally to invest sizable funds in leases on semiproven drilling prospects and relatively smaller amounts in wildcatting. This course has not been feasible because of the shortage of available leases on semiproven properties. To maintain the planned balance of business risks, royalties on semiproven properties have been purchased as a substitute for leases.

Climax originally entered the oil business in cooperation with American Metal Co. and Maracaibo Oil Exploration Corp. J. M. Flaitz and R. B. Mitchell have acted from the beginning as participating agents and conduct business activities on the Gulf Coast from their Houston office. Both these men were successful independent oil operators who had been associated in Gulf Coast oil activities for many years prior to the time they became exclusively associated with the Climax group.

More than 80 pct of Climax oil investments to date have been for proven and semiproven properties concentrated in Louisiana, Texas, and Oklahoma. In addition, the department has participated in a modest wildcat drilling program on the Gulf Coast and to a lesser extent in other areas in conjunction with American Metal Co. Despite the somewhat disappointing results to date of the wildcat program, it is estimated that Climax has now accumulated more than 9.0 million bbl of reserves at a total cost that will result in attractive returns on funds invested.

Water supply pond, pressure plan, and tank battery are representative of waterflooding installations used for secondary recovery of oil. This location in the Payne-Ward district, Rogers County, Okla. is operated by the Climax-Brundred Waterflood Div.

Major attention in the past two years has been divided between waterflooding and semiproven royalty purchases. Waterflooding is a method for the secondary recovery of oil from certain older fields by injecting water into the oil formation and forcing to the surface the oil that could not otherwise be recovered profitably. Only under an unusual combination of favorable conditions can recoveries from an oil field be increased profitably by waterflood techniques. Furthermore, this type of production requires careful economic appraisal and subsequent skillful operation by experienced waterflood engineers. It takes time, patience, skill, and detailed knowledge of the technological art of waterflooding to succeed. Climax stands in a favorable position here by virtue of its association with Maracaibo and with L. L. Brundred.

Most of Climax's waterflooding activities have been made in cooperation with Maracaibo. In December 1954, however, Climax acquired sole ownership of leases and facilities covering several thousand acres in northeastern Oklahoma formerly owned by the Whitehill Oil Corp. These properties are now producing approximately 1500 bbl per day. Their full development will take about three years when production should reach a peak of more than 3000 bbl. The Climax-Brundred Waterflood Div. was formed to manage these properties; most of the former employes of Whitehill Oil Corp. were retained, and additional personnel has been hired.

Climax usually takes a fractional participation in properties on a joint-venture basis. Except for the Oklahoma properties managed by the Climax-Brundred Waterflood Div., Climax does not operate any of its oil properties in its own name. During the past four years Climax has been spending substantially all its net oil income on development and further search for additional oil and gas. It is expected, however, that in the near future the oil dept. will begin to make significant contributions to earnings and will justify diversification through entry into petroleum.

Eastern Operations

Research & Sales — Key to Climax Growth

R. E. Warriner

Vice President in Charge of Sales

IN the late 19th century Fremont Pass was only a gateway to Leadville, Colo., 12 miles to the north. Some of the silver, lead, and zinc won from this famous camp crossed the Continental Divide at Climax, passing by the huge outcrop of molybdenum on Bartlett Mountain. This element, relatively unknown in the world of commerce, was then nothing more than a joke to play on greenhorn prospectors. Even 30 or 40 years later, after the demand for metals created by World War I had forced temporary use of molybdenum as an alternate for tungsten in tool steels, the Bartlett Mountain outcrop once again became merely a curiosity.

With the persistent efforts of Brainerd Phillipson, for years the president of Climax and almost the only employe, use of molybdenum gradually began to grow, first in tool steel and later in the alloy steels required by the growing automotive industry. Mr. Phillipson was first an engineer and second a salesman. The combination of these two qualities is the key to the story, not only of Climax sales but also of the growth of molybdenum from an object of idle curiosity to the point where it is today, along with chromium and nickel, one of the most versatile alloying elements in the iron and steel industries and increasingly important in chemistry.

Twentieth century demands for power and speed have stimulated metallurgical and chemical development to establish new applications for metals. Since this is particularly true of molybdenum alloys, research and market development have been ably used by Climax to promote and increase the sale of its products. The market development of molybdenum alloys and chemicals requires a competent technical approach, and for this reason the Climax sales dept. has always been staffed with metallurgical and chemical engineers.

Uses for Molybdenum Expanding

From this approach have come many and varied discoveries. First, of course, are the alloy steels and tough high-temperature molybdenum-base alloys with superior properties to serve in the hot end of jet engines and gas turbines. The addition of 0.5 to 3.0 pct of molybdenum in stainless steels adds measurably to corrosion resistance, while similarly small quantities in alloy steels contribute to superior mechanical properties at both normal and elevated temperatures. Many foundries using gray iron have found molybdenum the best alloying element to improve strength and decrease section sensitivity. In chemistry, applications appear to be limitless. Molybdenum is already well established as a catalyst and a pigment, and good beginnings have been made in lubrication and agriculture.

Molybdenum disulphide, a postwar development, has lubricating properties where present materials are ineffectual and is expanding the scope of high temperature and extreme pressure lubrication. In the last ten years agronomists have found that molybdenum chemicals added to soils in amounts of only 1 or 2 oz per acre can increase yields of crops and forage from 30 to 600 pct.

To carry out its expanding role, the sales dept. has recently divided its responsibilities into two categories: commercial sales and market development. To service its commercial relations in various markets the sales dept. is staffed with specialists in such basic fields as the steel, iron, and chemical industries. These specialists are responsible for customer relations within their respective fields. The primary products sold to the trade are oxide and ferromolybdenum. Oxide is used largely in the steel trade and for ease of handling is canned in units of 20 lb of contained molybdenum. Many customers prefer this same oxide pressed into briquettes together with a self-reducing mixture.

Market development is handled differently, since requirements generally originate with the ultimate consumer of molybdenum alloys. For this reason in the metallurgical market div. each industry, such as automotive, railroad, steel is detailed to a specialist, whose assignment is nation-wide. The chemical market development div. is assigned by products, such as catalysts, lubricants, and agriculture. Thus the two market development divisions are constantly seeking and encouraging new uses and applications for the product in the actual field of consumption.

World consumption of molybdenum has risen from less than 20,000 lb in 1921 to more than 40 million lb in today's markets. For the most part, this consumption has been within the iron and steel markets in engineering alloy steels, tool steels, steel castings, stainless steels, and gray and malleable cast irons. Here the principal role of molybdenum has been either to increase strength and toughness, or to improve heat and corrosion resistance. The growth within these markets has not yet been consummated, particularly in Europe, where industrial recovery and expansion are rapidly progressing. As an example, the steel industry has recently proposed to exploit the markets for plate products in heat-treated alloy steel. Heretofore these were serviced by carbon or high-strength steels furnished in the as-rolled condition. Within this plate market alone lies a potential of several million pounds of molybdenum per year.

Supplemental to the steel and iron markets, unique and varied new uses for molybdenum are developing that promise to widen and diversify its usefulness. The multivalent molybdenum atom offers extraordinary possibilities in new chemical compounds. Today it is already performing as a catalyst

in the oil industry, as a trace element in plant nutrition, and as a base chrome-molybdate orange pigment, and its future as a corrosion inhibitor is promising. These and other chemical markets are forecast to require in 1960 some 8 million lb annually, compared to 2 million today.

For some years the extraordinary properties of metallic molybdenum have challenged and defied scientists. Though relatively uncorrodible, with a melting temperature of 4730°F, and a modulus of elasticity of 46 million psi, it defied processing by other than powder metallurgy for many years because of its high melting point and tendency to oxidize. Within recent years Climax engineers have perfected an arc-casting process, and large workable ingots have opened access to new markets for molybdenum and molybdenum-base alloys. With protective coatings these alloys can perform at temperatures of 2100°F and are operating in experimental jet engines. Already about a million pound per year is serving usefully in the electronics and glass industries, while the structural or tonnage application is yet unexplored.

Within recent years there has developed a great need for specialty alloys to resist heat and corrosive atmospheres. In many of these alloys molybdenum has become an important ingredient, adding measurably to heat or corrosion resistance. The Hastelloys, 16 pct Cr-25 pct Ni-6 pct Mo, and recent molybdenum-bearing Nimonics are among the group. Use of these alloys in industry is expanding rapidly and already accounts for several millions of pounds consumption per year.

Thus the element contained in Bartlett Mountain, virtually useless only 30 years ago, has become one of the most important in today's commerce. Its contributions are no longer limited to the field of iron and steel—its full usefulness is still to be found.

Eastern Operations

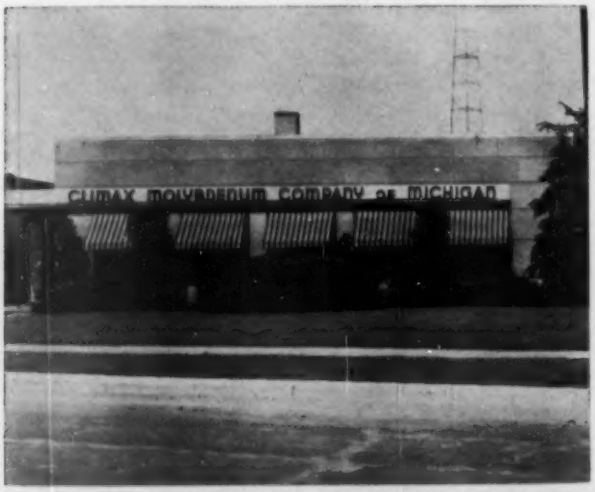
Detroit Research Laboratory

A. J. Herzig

Vice President in Charge of Research

PRODUCTS marketed by Climax are virtually all purchased for consumption by the metallurgical and chemical industries. Company policies demand that promotion of sales to such markets be based upon a sound technical background and to this end the company operates the Detroit laboratory of Climax Molybdenum Co. of Michigan. Discovery of the means of translating the technical potentials of molybdenum to molybdenum markets is accepted by the staff as a primary challenge.

The laboratory has a metallurgical and chemical staff of 60 with facilities for conducting research and development of markets for its products, and providing technical services to customers. Work of this type constitutes the largest single research effort of the company. The balance of the work is technical investigation of mining, ore beneficiation, and refining operations that is normally conducted by the Golden research, mine, and Langeloth planning groups in coordination with the heads of departments concerned.



Main building of the research laboratory of the Climax Molybdenum Co. of Michigan. Development of new and improved applications is a continuing program.

Administrative Committee Establishes Research Goals

Broad programming is an essential feature in conducting the work of an industrial research laboratory. This can be accomplished only at the administrative level. Continued expansion of the market for molybdenum depends upon coordinating the efforts of the various phases of the company to reach the target. To accomplish this, a six-man administrative research committee—composed of the president of the company, executive vice president, vice presidents of sales and research, chief metallurgist, and director of the Detroit laboratory —holds quarterly meetings to study research progress and map future programs. From time to time the committee selects additional Climax specialist personnel to participate in the meetings so that projects will receive complete consideration.

At these regular meetings the committee evaluates each project to determine: 1) scope of the program, 2) emphasis on various projects and field of effort, 3) acceptability for research by contract from other agencies, 4) placement of research contracts with other agencies, 5) cooperation required from other Climax departments.

Responsibility for carrying out the recommendations of the committee is assigned to the executive in charge of the particular function. Such an administrative policy makes the research dept. an integral part of Climax operations.

Organization Is Key to Successful Research

Operation at the Detroit Research Laboratory is organized to bring group action to bear on all problems reaching the laboratory. Effective group action requires that the communication lines within the

organization reach all the laboratory workers and that these lines be employed freely in both directions. Intimate transfer of information permits an extension of the degree of freedom that can be granted to individuals and departments without sacrifice of team action.

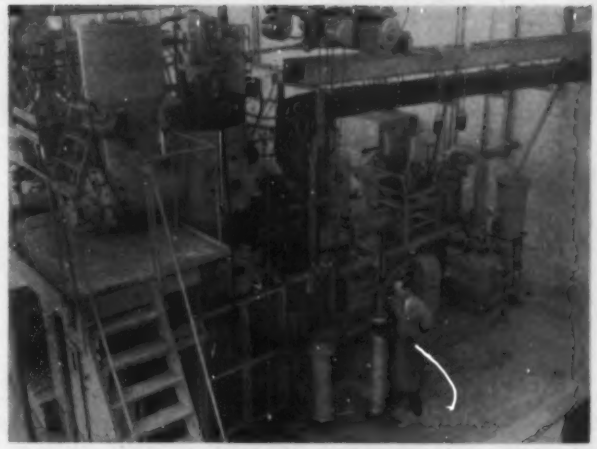
Technical Problems Encountered Are Numerous

Use of molybdenum in steel and iron as an additive alloy faces competition from manganese, chromium, nickel, and to a lesser extent, vanadium and tungsten. Determining relative merits of various alloying elements is a highly technical matter, complicated by the inherent problems of mass production operations. For this reason the research program normally contains projects relating to the use of molybdenum in alloy steel and cast iron and requiring up to 20 pct of the research effort at the laboratory.

The use of molybdenum in areas of chemical technology has shown considerable promise in recent years. Molybdenum oxide is used as a catalyst, molybdenum sulphide as a lubricant, molydates as corrosion inhibitors, and organic compounds as pigments. Potential uses are being developed for some new compounds. The rapid growth of chemical applications consumes 20 pct of laboratory time.

In the last ten years it has been found that molybdenum metal and its alloys constitute the strongest high-temperature metal currently available. The requirement of such alloys in defense items utilizes 20 pct of the laboratory time for this area of metallurgical investigation. As a corollary to this, 15 pct of the time is being devoted at present to the pilot production of experimental samples of molybdenum-base alloys, pending the establishment of commercial facilities by Climax or others.

Throughout its 25-year existence the Climax laboratory has engaged in technical service to the company's customers. This activity gives substance to the services that the field engineers can extend.



Close-up of vacuum arc-casting equipment used in experimental program at the Detroit Laboratory. In lower center of photograph the mold and casting after separation are shown.

Sponsored research for market development at the present time includes several projects on molybdenum agronomy and a few highly specialized ones in the testing of high-temperature metals.

Technical activity in the Detroit laboratory is divided into the following categories: 1) research projects in the use of molybdenum in alloy steels and irons, 2) research projects in the use of molybdenum in chemical technology, 3) research projects on molybdenum metal and molybdenum-base alloys, 4) technical service to customers, 5) pilot production of experimental molybdenum products, and 6) fundamental and exploratory research.

In research operations there is no substitute for the environment that fosters a creative spirit. The diligence, the loyalty, and the perseverance which must be added to technical competence to achieve an effective research team are characteristic of the Climax group.

Eastern Operations

Langeloth Conversion Plant

E. S. Wheeler

Vice President and General Manager of The Climax Molybdenum Co. of Pennsylvania

WITH the iron and steel industry as the largest consumer of molybdenum, Climax's processing plant was located where 75 pct of the output could be delivered to customers overnight. The smelting and refining plant was built in 1924 at Langeloth, Pa., about 30 miles west of Pittsburgh. The 500-ft candy-striped stack erected in 1943 makes the plant a landmark for airline pilots.

In the past 30 years the installation of the Climax Molybdenum Co. of Pennsylvania has become the largest molybdenum conversion plant in the world. The initial roasting operation in a hand-operated furnace capable of producing 600 lb of molybdenum daily has been replaced with six mechanically rabbled furnaces with 170,000 lb per day output. The shovels, wheelbarrow, and manpower of the original operation are now conveyors, power equipment, and push-button devices for material handling.

Number of Products Expanded

Initially the entire operation at Langeloth was devoted to calcium molybdate production, but in recent years the products manufactured have increased in number to meet the requirements of industry. These include: ferromolybdenum; technical molybdic oxide in barrels, cans, and bags; molybdic oxide briquettes; sodium molybdate; molybdenum silicide for alloying purposes; nickel-molybdenum and cobalt-molybdenum master alloys; purified molybdenum disulphide for lubrication; and technical thermite molybdenum. The nickel-molybdenum and cobalt-molybdenum master alloys for introducing molybdenum into nonferrous alloys were first offered in 1949. Due to shortages of nickel and cobalt, production of these materials was discontinued and they were replaced by thermite molybdenum in 1953. Limited quantities of ammonium

molybdate, molybdenum carbonyl, molybdenum pentachloride, and other specialty products have been made for experimental purposes. Langeloth is not making the molybdates at present, but they are manufactured by other companies.

Process control has improved with the development of the roasting operation. Sulphur in the roasted concentrate averages 0.05 to 0.08 pct on a monthly basis and rarely exceeds 0.10 pct in any daily lot. This is attained by drawing controlled quantities of air across the hearths, as contrasted to normal passage of all air up the furnace column. Provision for air flow across the hearths has also increased furnace capacity and enabled closer control of critical temperatures.

Temperature control is critical because molybdic oxide begins to sublime at about 1100°F, is volatile at about 1300°F, and melts at approximately 1460°F. These high temperatures result in excessive volatilization and serious operating difficulties. Good temperature control simplifies production problems and gives longer roasting campaigns. Although excess air across the hearths results in an increase in dust load, overall roaster recovery is close to 98 pct. Technical molybdic oxide is the product of the roasting furnaces. About 25 pct is marketed as such; the remainder receives further treatment.

Molybdic Oxide Basis for Other Products

Calcium molybdate was first made by mixing roasted concentrate, quicklime, and water in controlled proportions. This mixture was heated in a coke-fired oven to form a product containing about 40 pct molybdenum. Later practice introduced the lime into the roasting furnace, after sulphur was eliminated, to produce essentially the same product. Still later it was found that a suitable product could be made by mechanically mixing uncalcined pulverized limestone of high quality with roasted concentrate. This practice is used now to produce the amount needed to meet sales demand.

Molybdic oxide briquettes are a major product of Langeloth. For this operation technical oxide, mixed with airfloated pitch as a combined binder and reducing agent, is subjected to a pressure of about 10,000 psi. Two hydraulic presses, each with a capacity averaging 12,000 lb of molybdenum per shift, produce briquettes containing 2.5 lb of Mo.

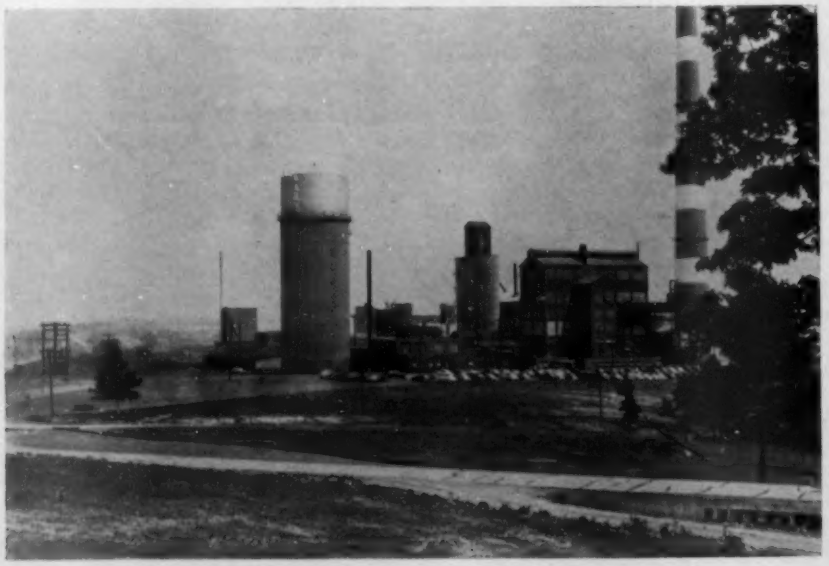
For the production of pure molybdic oxide, advantage is taken of the low sublimation temperature of molybdenum oxide. By subjecting technical molybdic oxide to a temperature of 1800°F to 2100°F, pure molybdic oxide is driven off, leaving impurities behind. This operation is carried out on the revolving hearth of a doughnut-type electrically heated furnace. The heating elements are Globar resistors suspended horizontally 10 in. above the moving hearth. After cooling, the volatilized oxide is collected in a bag filter. It is a fine, light product which, when mixed with a minimum of distilled water and dried, has an apparent density about seven times that of the original product. The densified oxide is packed in 200-lb drums for marketing.

Ferromolybdenum is produced by a silico-thermite process. Starting with heats containing 50 to 100 lb of molybdenum in 1928, the size has been increased until today, heats of 1300 lb contained Mo are made. Capacity of this department is 13,000 lb contained Mo per shift.

The smelting pot is a bottomless carborundum brick-lined shell under a portable hood and over a shallow saucerlike pit of sand. The well mixed charge is put into the smelting pot and ignited with a starting fuse (Al and Na_2O_2 or hot slag from a previous heat). Reaction is rapid and active. Top firing practice results in a heat being complete in 5 min or less. Following removal of the portable hood, the smelting pot is lifted, allowing all slag to remain on top of the molten alloy collected in the sand pit. After 8 hr the slag-capped alloy button weighing 2000 to 2100 lb is lifted from its pit by crane-operated tongs. The sintered sand skull adhering to the bottom of the alloy button is partially removed prior to quenching. The entire mass of alloy and slag is then dunked in circulating water tanks. After 30 min the quenched mass is removed from the tank. Normally, the cooled slag cap lifts cleanly from the alloy button, which is then set aside to steam off water adhering to the metal or within the quenching cracks. Fine fractures or quenching cracks facilitate hand-sledging to pieces of convenient size for further handling. Crushing in jaw and cone crushers produces the various sizes of ferromolybdenum.

Smelting Operation Constantly Improved

The smelting operation has been constantly improved. More desirable working conditions have



Climax's processing plant at Langeloth, Pa., is capable of producing 170,000 lb of Mo per day. Molybdenum was first treated here 30 years ago in a hand-operated furnace with an output of 600 lb daily. It has become world's largest Mo-processing installation.

been insured by enlarging baghouse facilities and installing automatic control equipment. Fan capacity is such that, except for an occasional fast heat, little dust escapes into working areas.

Until 1946 all slag was stored on an outside dump. Some 50,000 to 60,000 tons were accumulated. Equipment installed to treat slag for metal inclusions was first used only for current production. A four-wheel drive, rubber-tired, hydraulic-lift, 1-cu yd capacity tractor shovel was found practical for returning slag from the dump to the slag-metal recovery unit. Addition of a drier for fines from the dump completed the alterations for treatment of the outside slag. Treatment of slag from outside storage began in volume early in 1952 and was virtually completed by January 1955. After the summer of 1955, only current slag will be treated.

Slag is crushed and separated into four sizes; then each size is treated on an air concentrating table, returning the metal concentrate to production. Middling product is returned to the slag circuit and tailing products go to waste.

Other alloy products such as molybdenum silicide, thermite metal, and special alloys, are produced much the same way as ferromolybdenum. Sodium molybdate was produced by the conventional process of dissolving technical molybdic oxide in caustic soda, filtering, evaporating, and drying.

The 30-year total for shipments of products has been about 292 million lb of contained molybdenum. The number of employes has ranged from six in 1924 to more than 300 in 1942, the peak year. The management is proud of the fact that labor turnover has been very low and Langeloth's safety record is outstanding.

Working Conditions Considered Vital

Climax management, always sympathetic to practical means of making conditions better, within and without the plant, has instituted numerous changes and improvements in fume elimination and dust control. Within the plant, packaging centers are individually equipped with dust collectors to make work more agreeable for employes. In addition to improvements and progress in the smelting and refining div., the laboratory and offices have been modernized.

Technical staff members hold memberships in national and many local technical societies. Attendance at meetings provides many contacts which prove enjoyable as well as profitable. Plant visits by various societies and school groups through the plant have been encouraged and planned by the staff. Visits to neighboring mills by the technical staff and foremen have proved interesting and instructive.

A monthly issue of *Climax News*, originally published for the benefit of World War II service men, is now printed as a special page in the local newspaper and also mailed to each employe's home. In addition, a monthly safety bulletin is published.

Eastern Operations

Molybdenum Works for the Mining Industry

T. E. Norman

Metallurgist

A SIGNIFICANT proportion of the molybdenum mined at Climax finds its way back into mining and milling operations, where it serves to increase the strength and wear resistance of many of the steel and iron parts used. Climax operating, sales, and research departments conduct joint programs with the dual objective of obtaining more economic materials for use in Company operations and at the same time developing further uses of molybdenum.

There are two general fields of application for molybdenum in the mining industry. One is in the engineering grades of steels and irons where molybdenum is used principally to improve properties such as strength and toughness. Since this use is well established, and not peculiar to the mining industry, the only example of this class to be discussed will be hollow drill steel. The other general field is in abrasion-resistant materials, which are so essential to the mining industry.

Molybdenum Uses Based on Good Engineering Properties and Abrasion Resistance

In the case of hollow drill steel, a large tonnage replacement item in the mining industry, there has been a definite trend toward the use af alloy steel compositions containing molybdenum. When the

Abrasion-resistant steels are becoming increasingly important in the mining industry as greater tonnages are produced. Wearing parts of dipper buckets and truck bodies take severe punishment and for such service, alloy steels containing molybdenum are being developed to give longer life.

adoption of this alloyed drill steel is combined with proper practices in the design, fabrication, and heat treatment of the drill rods, it has usually been possible to obtain a substantial increase in rod life. These alloyed drill steel compositions have been particularly helpful when drilling is done with carbide insert bits, where frequent rod breakage could be costly.

Liners for ore cars, truck bodies and skips, chute liners, slusher scraper parts, wearing parts of dipper buckets and the lowly, but still important hand shovel require a combination of good engineering properties and abrasion resistance. For such service various alloy-steel compositions containing molybdenum have been developed. These may be wrought or cast, depending upon design and economic considerations, and are almost invariably heat treated at the producer's mill or foundry.

Large tonnages of abrasion-resisting alloys are consumed by the mining industry in the crushing and grinding of ore. For most of the crushing operations, Hadfield manganese steel is used in the crusher liners. This alloy, which combines high toughness with moderately good wear resistance, has been extremely useful despite its tendency to flow under high-stress. Recent laboratory and field tests have indicated that molybdenum additions offer much promise as a means of improving resistance to flow as well as wear resistance.

The grinding mills used in most milling operations will generally account for more than half the total metal consumed by a mining company. For the abrasion-resisting materials used in these mills, molybdenum has become well established as an alloy in both rolled and cast high-carbon chromium-molybdenum steel for ball and rod mill liners, in chromium-molybdenum steel discharge grates, and in the larger sizes of fully hardened, forged steel grinding balls. In the rod and ball mill liners still greater use of molybdenum is indicated for some of the harder, more wear-resistant types of liners now under development.

Moly Alloys Reduce Climax Operating Costs

Four specific examples are perhaps typical of the many uses of alloyed materials at Climax.

Excellent results are being obtained from high-carbon chromium-molybdenum hollow drill steel. Climax has also found that a carburized alloy steel, purchased as made-up rods, will give outstanding service for certain drill-rod sections. Mine car bottoms are subject to severe impact loading, along with abrasion, by the large chunks of ore dropped from the slusher hoppers. The life of these bottoms has been increased 300 pct by lining them with welded-on strips of molybdenum steel heat treated to about 360 Brinell.

Cone crusher liners of Hadfield-type manganese steel are a major replacement item at Climax. Many fail by cracking, which may be due to the low yield strength of the alloy. Current indications are that this cracking can be reduced by adding about 2 pct molybdenum to the steel. Ball mill liners, another major replacement item, must have relatively good toughness and spalling resistance under the operating conditions used at Climax. High-carbon chromium-molybdenum steel at about 375 Brinell has given consistently good service here for many years.

During the past decade cost of replacement parts and cost of shutdown time for repairs and replacement have both increased more rapidly than the cost of molybdenum and the other alloying elements. Consequently, the use of alloy steels and irons where they show better service life will yield greater economic advantages at present than ever before. With these factors as an incentive, the operating departments at Climax, in cooperation with the metallurgical research and sales departments, are striving to develop alloy steels and irons which will give better parts life for the mining industry.

Application of Geology to the Discovery Of Zinc-Lead Ore in the Wisconsin-Illinois-Iowa District

Detailed stratigraphic studies in the Wisconsin-Illinois-Iowa district have made it possible to map the folds and faults that controlled the deposition of the zinc-lead ore. Prospecting on the basis of this mapping and prospecting in lower zones that are potentially ore-bearing have led to discoveries of ore.

Allen F. Agnew

GEOLOGIC studies for the Federal and State governments in the Wisconsin-Illinois-Iowa zinc-lead district were begun in 1835, and subsequent surveys were made in the three states at intervals until 1916, see Table I.

The current study of the district, Fig. 1, by the U. S. Geological Survey was begun in 1942 in the hope that a systematic investigation would help increase production of zinc and lead, then in extremely short supply. Major emphasis of the USGS program was on detailed mapping of the geologic structure and ore deposits. Preliminary maps and reports covering localities of intensive mining activity have been published during the course of this study, Fig. 2. By 1950 the objectives of the study by the USGS were revised; 7½-min quadrangles of relatively unprospected localities as well as intensively mined localities are now being mapped in Wisconsin. Since 1945 the investigation in Wisconsin has been made in cooperation with the Wisconsin Geological and Natural History Survey, and since 1951 the geologic mapping of areas of particular interest in Iowa has been performed in cooperation with the Iowa Geological Survey. At intervals since 1943 the Illinois State Geological Survey has mapped the geologic structure and ore deposits of localities in the Illinois part of the mining district, see Fig. 2.

Geology was applied by mining company personnel as early as 1853, but only sporadically, with periods of greater application between 1890 and 1925. Much of the so-called geologic work was in reality mining engineering. Since 1946 the major mining companies in the district have employed geologists who have successfully applied geologic techniques in the search for ore.

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Discussion on this paper, TP 4045 I, may be sent (2 copies) to AIME before Oct. 31, 1955. Manuscript, Aug. 13, 1954. Los Angeles Meeting, February 1953.

History of Mining

Occurrence of galena in the district was known as early as 1658 or 1659, when French explorers heard of lead mines that were apparently in the vicinity of Dubuque, Iowa. In 1690 a trading post was established near Dubuque to obtain galena. The first significant attempt at mining by white men took place in 1788 when the Indians granted to Julien Dubuque mining rights for 20 miles along the west side of the Mississippi River, including the vicinity of Dubuque, Iowa. By 1805 lead was being mined near Galena, Ill. In 1819 permanent settlement of the region was begun, and most of the important lead-producing areas had been found by 1830, see Fig. 3. Lead production in the Wisconsin-Illinois-Iowa district between 1830 and 1871 far exceeded that of any other district in the U. S.[2]

Smithsonite was first mined in 1859, and sphalerite was mined as early as 1867. After 1873 the production of sphalerite exceeded that of smithsonite.

In 1873 annual zinc production from the district first equaled lead production, and from then until 1893 production of zinc and lead was roughly the same. Since 1893 the ratio of zinc to lead mined has generally ranged between 5:1 and 20:1.

In 1942 the Wisconsin-Illinois-Iowa zinc-lead district ranked 14th among zinc-producing districts of the U. S. From 1946 until February 1953 the dis-

Table I. Former Significant Geological Surveys and Their Major Emphasis

Geologist	Wisconsin	Illinois	Iowa
Owen[3]	First general survey of the mining district (Fig. 3)		
Percival[4,5]	Alignment of lead-producing areas		
Whitney[10, 20, 22]	Detailed descriptions of lead-bearing crevices		
Strong[23]	Detailed description of mine workings		
Chamberlin[24]	General geologic conclusions		
Calvin and Bain[21]			Detailed study of vertical joint (crevice) deposits—lead and zinc
Grant[26]	Mapped folds that control zinc deposits		
Bain[25]	Mapped folds that control the zinc deposits		
Cox[30]		Showed localization of ore deposits in areas of thick oil rock	

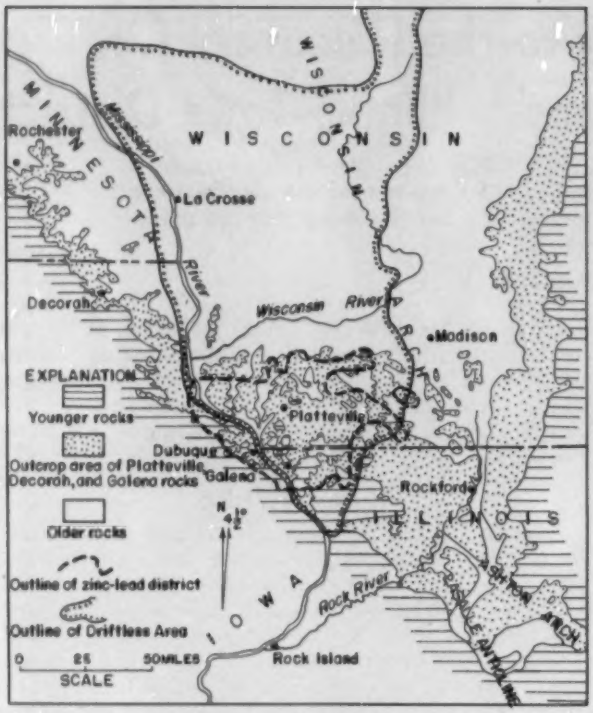

Fig. 1—Map showing relationship of the Wisconsin-Illinois-Iowa zinc-lead district to the outcrop pattern of ore-bearing strata (Platteville, Decorah, and Galena formations) and to the driftless area. (Taken in part from State geological maps, Willman and Templeton.[3])

trict ranked generally as the seventh leading producer of zinc. It ranked 14th among the lead-producing districts in February 1953.

Copper was mined intermittently from 1837 to about 1909, as mixed ore containing copper carbonate and oxide minerals. The principal mines were at Mineral Point, Wis., Fig. 2, where mining ceased in 1880. Copper in the zinc-lead district has been little more than a curiosity, and shipments of the ore probably did not exceed 10,000 tons, of which some lots assayed as high as 20 pct Cu.

Geology

Owen[2] noted that the lead deposits were confined to the area of outcrop of the middle and lower beds of his Cliff limestone, the Galena dolomite of present terminology, see Fig. 4. He subdivided this unit into cherty beds (below) and arenaceous or noncherty strata (above). Percival[4, 5] subdivided his Blue limestone (now the Decorah and Platteville formations) and since that time his excellent subdivisions have been vaguely or incorrectly used by some authors in an attempt to clarify the stratigraphy. In the course of the present survey a classification of rock units that is strikingly similar to that of Percival was devised for the Decorah and Platteville formations. Reinterpretation of existing subdivisions of the Galena dolomite, and further subdivisions of that formation, resulted in the present classification of that unit.

Pre-Cambrian Rocks: Granite was reported in wells at Platteville and Richland Center, see Fig. 2, at depths of 1714 and 665 ft, respectively. Pre-Cambrian granite was reported at a depth of 1800 ft in city well No. 5, Dubuque, Iowa.

Lower Paleozoic Rocks: Cambrian strata are exposed just north of the principal mineralized area, see Fig. 1, and underlie the mining district. The Cambrian rocks are mainly sandstone and siltstone and aggregate 1000 to 1300 ft thick, but they are not important potential host rocks for zinc-lead deposits.

The dolomite, shale, and sandstone of the Prairie du Chien group (Lower Ordovician) are exposed along the northern fringe of the major mineralized part of the district and in the more deeply incised river valleys in Wisconsin, Fig. 1. They underlie the remainder of the district. Dolomite in the Prairie du Chien is a potentially productive host rock for lead and zinc sulphides.

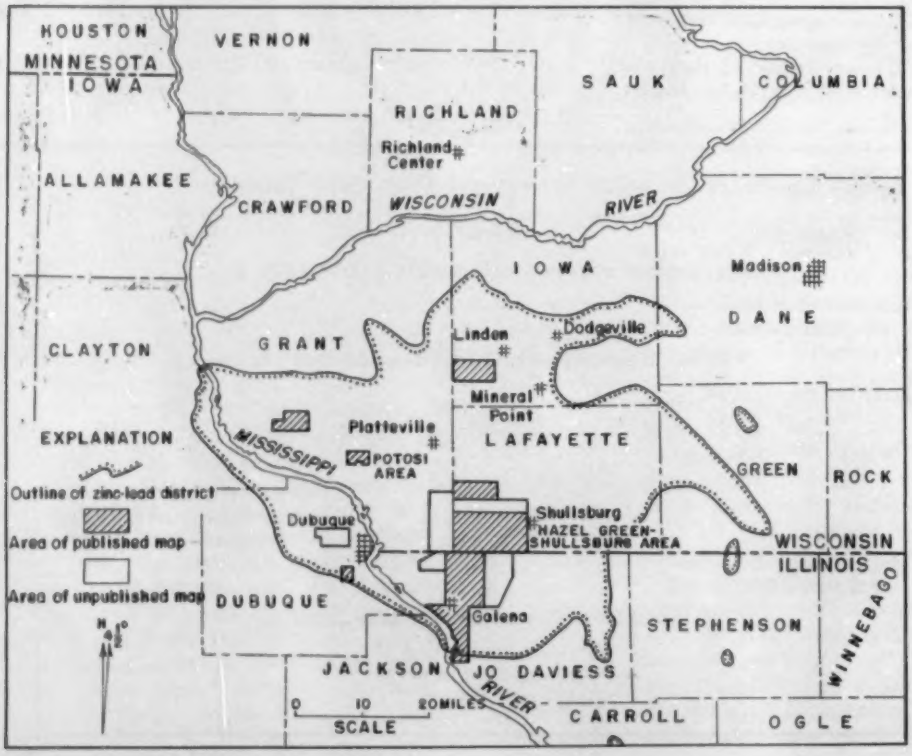

Fig. 2—Map of the Wisconsin-Illinois-Iowa zinc-lead district showing areas covered by published and unpublished geologic maps since 1942.

Areal distribution of the St. Peter sandstone of early Middle Ordovician age is similar to that of the Prairie du Chien. This sandstone is the major aquifer of the mining district, but there is small possibility that it bears zinc-lead ore deposits. The St. Peter and the underlying Prairie du Chien units vary inversely in thickness and together aggregate 270 to 325 ft.

The dolomite, limestone, and shale beds of the Platteville, Decorah, and Galena formations (Middle Ordovician) are at the surface in most of the mining district, Fig. 1; elsewhere in the district, except where erosion exposes the St. Peter and Prairie du Chien rocks, they are present in the subsurface. The Platteville, Decorah, and Galena rocks include all the currently productive strata of the zinc-lead district, and the subdividing of these formations into 18 lithologic units, Fig. 4, was a major step in locating the small folds and faults that controlled the emplacement of the ore. Thicknesses given are for unaltered rocks; alteration due to mineralizing solutions commonly has reduced the Guttenberg and Quimbys Mill members to less than 50 pct of their normal thickness and has likewise affected the McGregor and Ion members. Some of the lithologic units are recognized only locally (as certain subdivisions of the Cherty unit of the Galena formation) and others regionally (as the subdivisions of the Decorah formation). Potentially productive units include the Quimbys Mill member and the upper half of the McGregor member, which have not been prospected in many areas of the mining district despite the fact that ore in these beds was formerly mined in some areas.

Maquoketa strata of Late Ordovician age crop out along the northward- and northeastward-facing cuesta of Silurian rocks in Illinois and Iowa and appear on areal maps as doughnuts around the erosional outliers (locally called mounds) to the north and east, Fig. 1. Maquoketa beds are also present beneath the Silurian rocks south from the cuesta face, and at the center of each mound. The Maquoketa formation, which consists of shale and some dolomite, is not important as a potential ore-bearing unit. On the other hand, these beds can possibly be used to detect mineralized zones beneath, as at places concentrations of iron, lead, and zinc sulphides are found at the Maquoketa-Galena contact because the upward-percolating waters were diverted laterally at this contact.

Dolomite of Silurian age is distributed similarly to the Maquoketa but is slightly more restricted,

Table II. Significant Applications of Geology to Special Problems in the Wisconsin-Illinois-Iowa Zinc-Lead District

- ► Need for geologic background noted—Daniels (9)*, George (37).
- ► Potential value of zinc minerals recognized—Owen (3), Daniels (9).
- ► Relationships between ore deposits and synclines recognized—Whitney (10), Chamberlin (34), Blake (24), Winslow (2).
- ► Areal mapping of synclines—Grant (26), Bain (35), Grant and Perdue (38), Scott (20). (See Fig. 6).
- ► Relationship of faults to folds—Jenney (6), Behre, Scott, and Banfield (39).
- ► Relationship of thick *oil rock* to orebodies—Bain (35), Grant and Perdue (38), Cox (40), Scott (20).
- ► Production from lower zones ("glass rock," "Trenton") predicted—Daniels (9), Grant (27), Grant and Burchard (41), Cox (40).
- ► Possibility of production from "Lower Magnesian"—**Pro:** Owen (3), Daniels (9), Percival (4), Murrish (42); **Con:** Whitney (10), Chamberlin (34).
- ► Mining several crevices by a central shaft—Whitney (30).

* Numbers in parentheses indicate references.

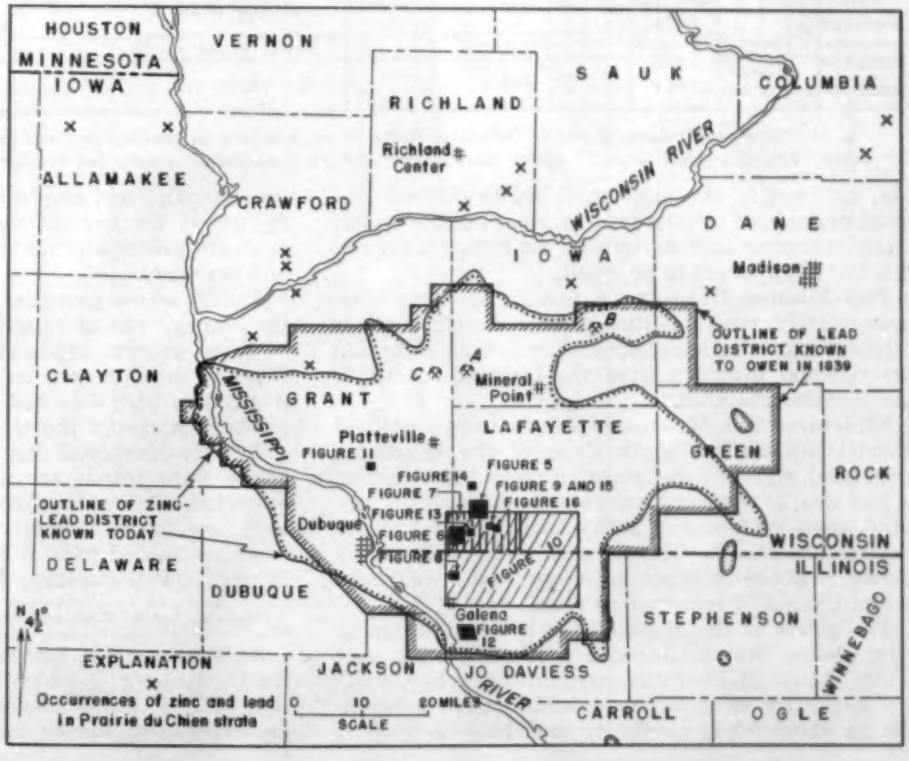

Fig. 3—Map showing lead district known to Owen in 1839, zinc-lead district known today, occurrences of zinc and lead in Prairie du Chien strata, and location of areas shown by Figs. 5-16.

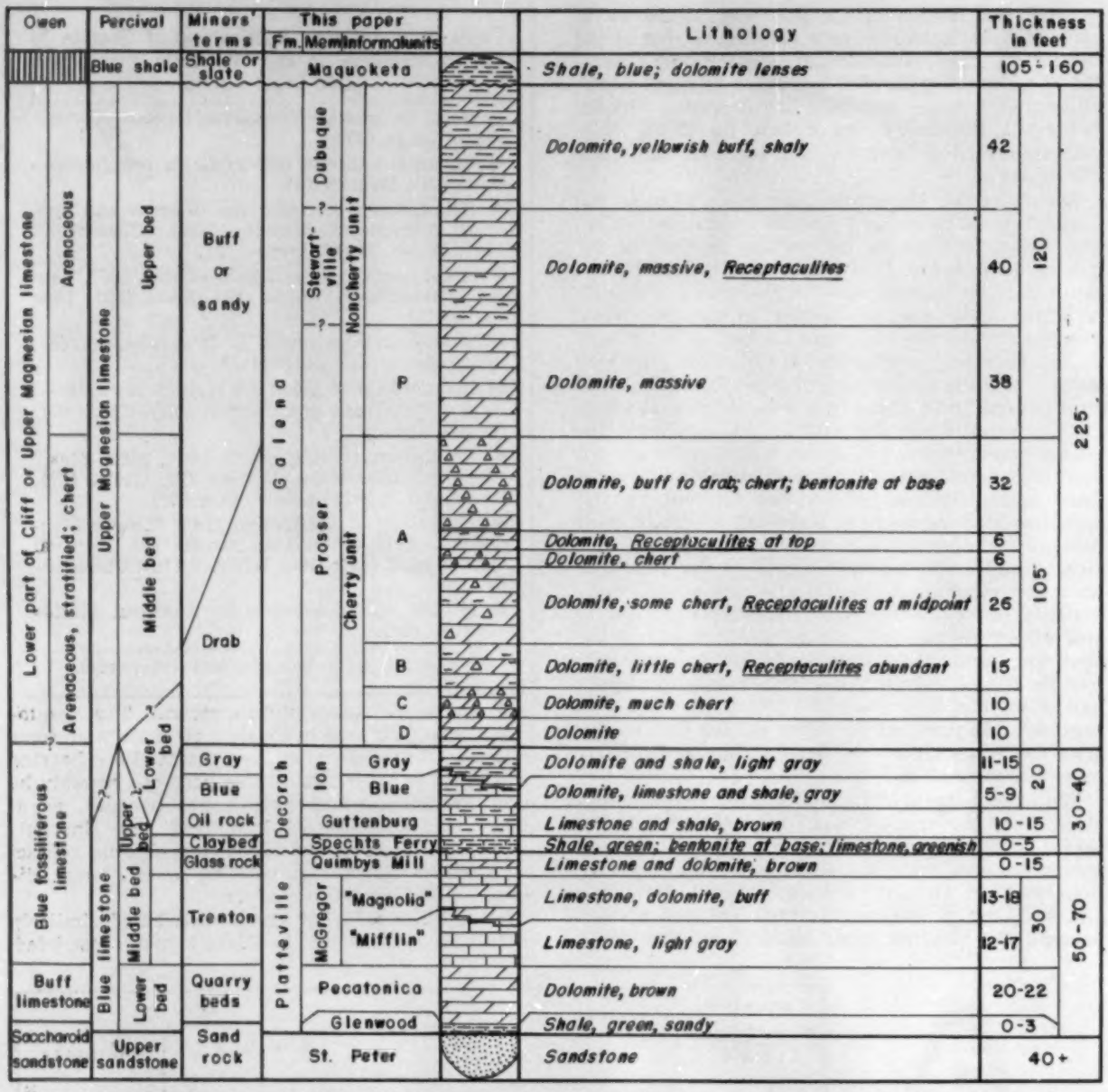

Fig. 4—Stratigraphic column of Middle Ordovician strata of the Wisconsin-Illinois-Iowa zinc-lead district showing Owen's classification,[3] Percival's classification,[4, 5] miners' classification, author's classification, graphic and descriptive lithology, and thicknesses.

Fig. 1. Vugs in the Silurian dolomite contain isolated crystals of sphalerite or galena, but the possibility of commercial deposits in the Silurian beds of this district appears to be small.

Post-Silurian Deposits: A mantle of Pleistocene loess covers most of the mining district and is thickest near the Mississippi River. This loess and the residual products from the bedrock constitute the surficial material.

Structure: The Wisconsin-Illinois-Iowa zinc-lead district lies on the south slope of the Wisconsin structural high of pre-Cambrian rocks. The district is just west of the southward extension of this structural high (Wisconsin arch) toward the LaSalle anticline in Illinois. The regional dip, first noted by Owen[3], is about 16 ft per mile south-southwestward across the major mineralized area.

The strata of the district have been subjected to compression that produced a pattern of folds and faults. Although the folds, mentioned first by Owen,[3] are generally of small magnitude (from crest to trough about 30 ft vertically and 1000 to 1500 ft horizontally) and most are local, many fold axes can be traced for several miles. The trends of these axes are principally northeastward, northwestward, and eastward.

Faults, whose potential economic value was noted by Jenney,[6] are of relatively small magnitude and of three general types—reverse, normal, and tear. Dip-slip displacement on the reverse faults is commonly less than 6 ft, but strike-slip displacement is greater; on one of the tear faults it is at least 35 ft.

A well-developed joint pattern is recognizable. Major joint trends are northwestward and northeastward. Subsidiary joints trend eastward, and a very few trend northward. Control of streams by fractures, noted near Richland Center (Fig. 2) by Hobbs,[7] is well displayed in certain areas, Fig. 5.*

* See also Agnew, Flint, and Crumpton.[8]

Rock Alteration: Limestone strata, particularly in the Guttenberg, Quimbys Mill, and McGregor members, Fig. 4, have been locally dolomitized by the ore-bearing solutions; the result is a sugary, more

coarsely granular rock. Dolomitic limestone strata illustrate effects of dolomitization in two ways: 1) by bleached areas that show a change from calcareous to dolomitic cement, without apparent change in grain size, and 2) by thin veinlets of fine-grained milky dolomite.

Leaching, especially of limestone strata in the Guttenberg and Quimbys Mill members, has locally resulted in thinning to less than 50 pct of the original thickness. More rarely, as little as 15 pct of the original thickness has been preserved, as shale and argillaceous residuum. McGregor and Ion strata have been similarly leached.

Silica was introduced locally by the ore-bearing solutions and resulted in two products: 1) silicified Guttenberg or Quimbys Mill beds that have the megascopic appearance of unaltered limestone and shale and 2) chert nodules particularly in the Guttenberg, but also in the Quimbys Mill member. Chert in the cherty unit of the Galena dolomite seems to be more abundant near areas that have been mineralized, although quantitative data have not been obtained.

Ore Deposits

Minerals: The ore minerals are sphalerite and galena. Minerals of possible economic value are smithsonite, pyrite, marcasite, and barite. Principal gangue minerals are calcite and limonite.

Lead Orebodies: Lead ore occurs as gash veins in nearly vertical joints (crevices of local terminology) in the noncherty unit and in the upper part of the cherty unit of the Galena dolomite, to depths of 70 ft or more below the topographic surface. The galena is present 1) as isolated crystals or clusters in a matrix of vuggy dolomite or dolomite sand and 2) as veins commonly less than an inch thick. Podlike masses of ore and rock, several feet wide, are present in leached rock at favorable stratigraphic horizons (openings of local terminology) and in a particular opening several podlike enlargements may occur along a crevice. Chimneys or pipes of galena are in some places found at the intersections of crevices. Individual crevices have been mined along their strikes for as much as 1700 ft. The great number of shafts along any particular mineralized crevice was due partly to the early miners' aversion to tramming long distances underground and partly to the small area of each claim. A striking example of the regularity of pattern of these mineralized joints is seen in Fig. 5.

Zinc Orebodies: Most of the zinc ore, with minor lead ore, has been found in the cherty unit of the Galena dolomite, in the Ion and Guttenberg members of the Decorah formation, and in the upper part of the Platteville formation (Quimbys Mill and McGregor members). The principal ore zones are 1) the lower 40 ft of the Galena dolomite and the Ion member and 2) the Quimbys Mill member. Ore occurrences along inclined fractures are referred to as pitches and those along bedding plane separations are flats. These fractures are on the flanks of folds and, like the folds, are believed to be due to compression. In the footwall area of the pitches, which is locally termed core ground, the minerals replaced the rock and filled vugs. These pitch-and-flat orebodies, which are mined as a unit that includes the pitches and the intervening core ground, are as much as 125 ft high, 450 ft wide, and two miles or more long, although an average length is perhaps 1000 ft.

Economic Application of Geology

For the following reasons the *apparent* limits of the Wisconsin-Illinois-Iowa district, Fig. 1, are not necessarily the *actual* limits of the potentially ore-bearing area: 1) The regional dip to the south is responsible for the absence of Platteville, Decorah, and Galena beds to the north. 2) The eastern limit appears to coincide generally with the boundary of the driftless area. Platteville, Decorah, and Galena strata extend toward the east, but are overlain by a variable thickness of glacial material, and the reticence of miners to prospect for zinc-lead deposits through this material is understandable. Zinc-lead deposits may be found east of the driftless area. 3) The southern and western limit of the district seems to coincide roughly with the face of the cuesta of

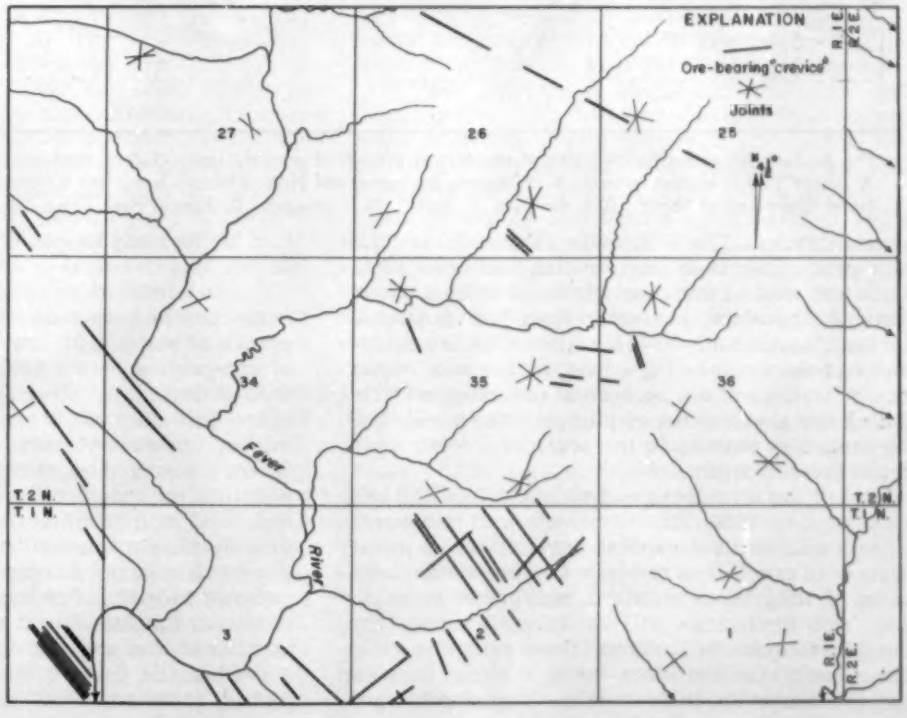

Fig. 5—Map of area southeast of Platteville, Wis., showing drainage control by joints and regularity of ore-bearing joint (crevice) pattern. (From Agnew, Flint, and Crumpton[8] and Heyl and Agnew.[40])

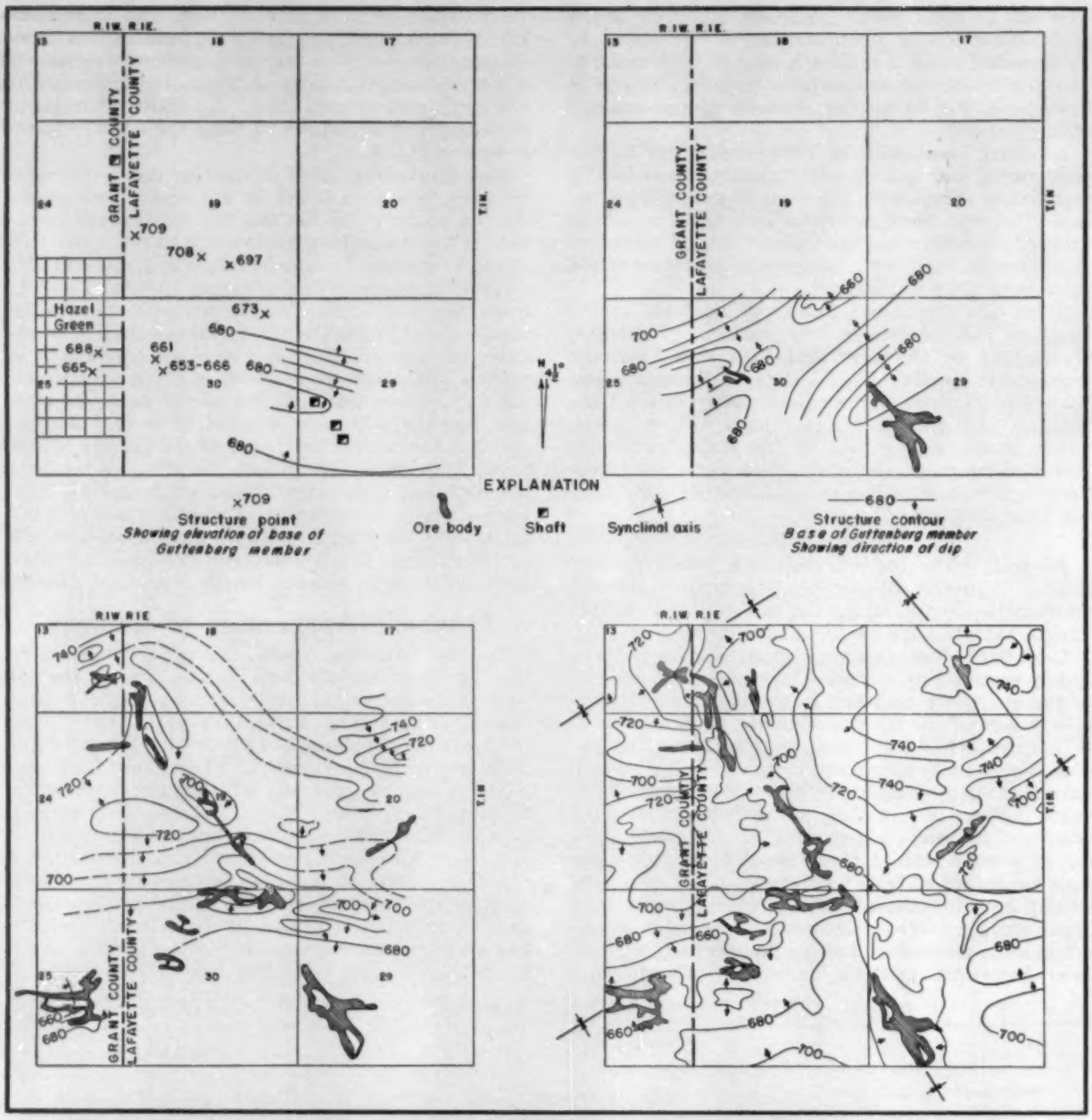

Fig. 6—Evolution of detailed mapping of structure as a result of greater density of data, southwestern Lafayette County (Fig. 3). A. Grant[38]; 10-ft contour interval. B. Wisconsin Geological and Natural History Survey and Wisconsin State Mining Trade School, Hazel Green Special Sheet[44]; 10-ft contours. C. Scott[39]; 10-ft contours. D. Agnew, Heyl, Behre, Lyons[35]; 20-ft contours.

Silurian rocks. The Platteville, Decorah, and Galena strata may bear lead or zinc orebodies to the south and west of this cuesta face. Economic considerations, therefore, presently limit the district on the east, south, and west, because of a) the greater depth of the ore-bearing strata, b) the lack of surface indications of ore because of overlying material, and c) the greater cost of pumping the water from the orebodies that lie to the south and west, owing to the greater depth.

Most of the principal areas of lead mines had been discovered by 1830. After that date lead mines were located within these general areas either on newly discovered crevices or on those already worked. Because of this, Daniels[9] felt it reasonable to expect that "rich discoveries will yet be made upon [the] unexplored grounds [between these general productive areas]." On the other hand, Whitney believed that this "seems to indicate that a considerable portion of the Lead Region is quite destitute of deposits of ore."[2][3][0]

Surface indications of lead and zinc deposits were numerous and obvious. This accounts for the discovery of many lead-bearing areas in the few years of prospecting before 1830. Most of these areas are well-dissected by streams, and the minerals were found in valley walls or on slopes. Other areas of mining, however, have been found on uplands, where plowing showed reddish-brown streaks in the wet soil, indicative of mineralized zones, or where float lead or iron minerals were brought to the surface by farming operations. With the boom in zinc mining that began during the 1890's, and the accompanying practice of prospecting by churn drills, exploration expanded into these upland areas, and a number of lead and zinc ore deposits were found.

During the first 70 years of prospecting in this district (1820's to 1890's) lead and zinc bodies were

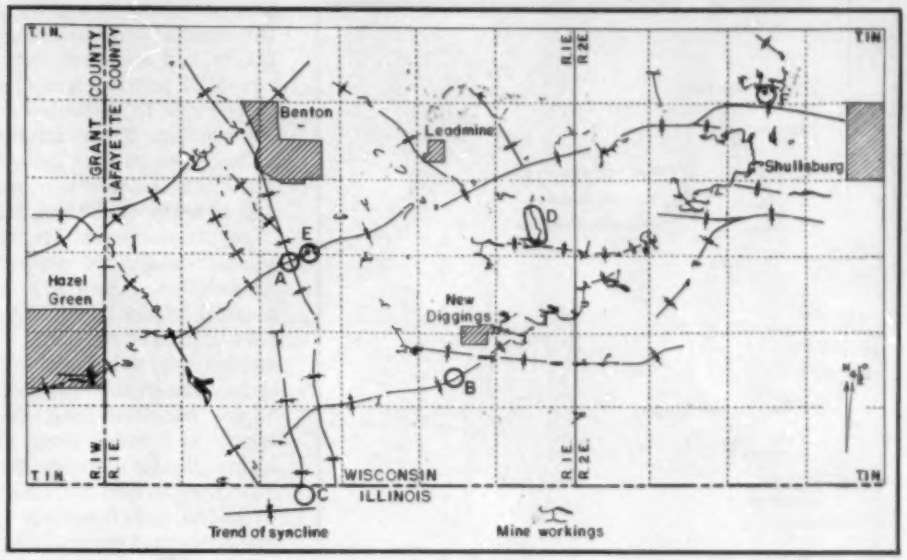

Fig. 7—Map of Hazel Green-Shullsburg area, Wisconsin, showing trends of synclines, zinc orebodies, and localities (A-F) discussed in text. (From Agnew, Heyl, Behre, and Lyons.[35])

found with relative ease. In the next 30 years increasingly greater difficulty was encountered in discovering zinc orebodies, and some geologic techniques were employed by the mining companies to increase the chances for a strike.

Pitch-and-Flat Zinc-Lead Deposits

Synclines: Owen[8] noted that the regional dip of the beds is "subject to undulations," Whitney[10] was the first to record the relationship between the ore deposits and synclines, and Grant was first to map synclines areally,** Fig. 6.

** Strong may have prepared such a map in 1873, for Lapham[11] stated that "Mr. Strong has prepared a map of the Blue Mounds . . . with the Brigham mines, showing geological formations . . . and also the topography by contour lines, and the depth at which each rock would be reached from any point."

Faults: The relationship of faults to the folds in the Wisconsin-Illinois-Iowa district and thus to the control of ore deposits was discovered by Jenney.[6]

Oil Rock: The Guttenberg member of the Decorah formation normally consists of 10 to 15 ft of brown thin-bedded limestone with intercalated brown shale partings, Fig. 4. Locally, as Kay first noted,[28] the limestone component has been leached, resulting in a concentration of brown shale and other argillaceous material; in such places the Guttenberg member is as thin as 2 ft. The *oil rock* of the miners is the brown shaly material. Therefore, in areas of thin Guttenberg, where the shale element is concentrated, miners recognize a thick oil rock; in areas of normal Guttenberg thickness, on the other hand, where the shale component is scattered and obscure, the miners do not recognize oil rock.

The association of many ore deposits with the leached Guttenberg member (or thick oil rock) is a feature useful in prospecting.

Areal Structure Mapping: In 1942 and 1943 the USGS began areal mapping of the folds that control the zinc-lead orebodies. The first locality mapped, selected for its large number of mines and closely spaced drillholes, was the Hazel Green-Shullsburg area in Wisconsin, Fig. 2. At first the folds were mapped on the basis of drillhole records, but because the persons who logged these early holes did not interpret the stratigraphic subdivisions consistently, it was necessary to restudy the stratigraphy in detail. In 1943 and 1944, with information obtained from mapping the geology of more than 40 mines in all parts of the district and from studying outcrops throughout an even more extensive area, the USGS determined the stratigraphic relations of the larger units and subdivided these units, Fig. 4, so that the small folds and faults could be more accurately mapped. During the next few years the Illinois State Geological Survey applied and extended this type of mapping in Illinois in the area just south of the Hazel Green-Shullsburg area, Fig. 2.

In Wisconsin the areal geology was mapped in detail. Owing to dissection and thin surficial deposits, outcrops are numerous, and as most of the holes were drilled in upland areas, geologic information was available in most parts of the Hazel Green-Shullsburg area. The detailed subdivision of the stratigraphic sequence made most exposures useable as data points for structure contouring, which in turn was used to establish the relation of the orebodies to the local folds and to delimit potential areas for exploration. Horizontal and vertical control was obtained by plane table and telescopic-alidade surveys, scale 1:7920. The mapping in Illinois differed in that vertical control was obtained by transit and telescopic-hand-level surveys; horizontal control was derived from the Galena quadrangle.

In 1946 Calumet & Hecla Inc. geologists began mapping the folds with information from prospect holes drilled on a grid pattern.[33] The grid is based on subdivisions of land survey measurements and is a rectangular net 660x1320 ft or 660 ft square. The Eagle-Picher Co. has used a square grid of 660 ft,[34] whereas The New Jersey Zinc Co. drills prospect holes on a grid pattern based generally on 1320-ft spacing. This drilling was designed to obtain uniformly spaced geologic data. Folds disclosed by this means, like those disclosed by outcrop mapping in other areas, are then prospected for ore deposits with more closely spaced drillholes.

Other companies have used a modification of the grid system. In places only a simple grid is used; in other places lines of drillholes are spotted to cross the folds or trends of orebodies. The mineralized areas are then explored with more closely spaced holes, and holes are drilled along the trend of the ore. Geologists of the Eagle-Picher Co. and the Vinegar Hill Zinc Co. are currently using this method with success.

Mapping in the Hazel Green-Shullsburg area[35] showed three general trends of synclinal axes—northwestward, northeastward, and eastward, Fig. 7.

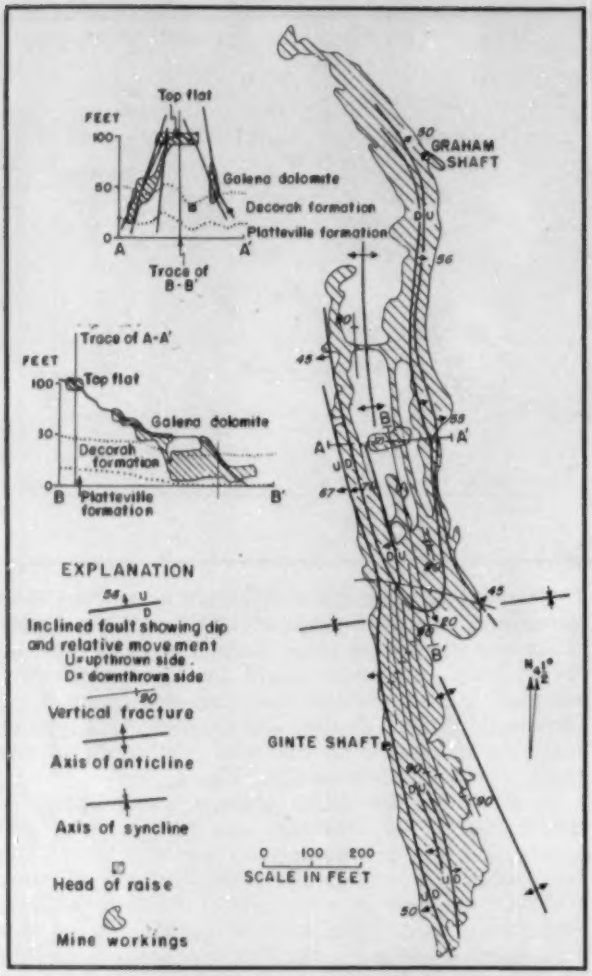

Fig. 8—Plan and cross-sections of Graham-Ginte mine, Illinois, showing opposed pitches and associated crenulated area and cross-syncline and spoon-shaped pitch. (Geology by A. F. Agnew, A. V. Heyl, Jr., E. J. Lyons, C. H. Behre, Jr., and R. M. Hutchinson, 1944-1945.)

In the northwest-trending synclines orebodies trend northwest. They are double-pitch† bodies that lie along a tightly crenulated zone, see Fig. 8; the central anticline is accentuated by steep normal faults and solution-thinned Guttenberg and Quimbys Mill members, see p. 784. The structure is believed due to tectonic compression and was modified by solution. These northwest-trending orebodies are as much as 3000 ft long, 450 ft wide, and 125 ft high, although the average orebody is about 1000 ft long, 200 ft wide, and 60 ft. high.

† *Double-pitch* faults are opposed outward-dipping reverse faults containing ore. One or more ore-filled reverse faults dipping in the same direction are known as *single-pitch* faults.

In the northeast-trending synclines, east-trending horseshoe-shaped orebodies, open to the west, occur *en echelon*. They are single-pitch bodies wrapped around broad folds, Fig. 9. The central part of the fold is broken by weak vertical joints. As very little evidence of solution is visible, the structure appears to have been the result of tectonic compression alone. These east-trending *en echelon* orebodies are as much as 2 miles long, 180 ft wide, and 85 ft high, although the average orebody is about 1200 ft long, 120 ft wide, and 50 ft high.

In the east-trending synclines, east-trending linear orebodies occur. They are single-pitch or double-pitch bodies, each controlled by crenulations that contain a gentle central anticline, which is broken by poorly developed vertical joints. If the orebody is double-pitch, one pitch is commonly much better developed than the other. As is shown in some mines, single-pitch structures have a complementary pitch-type fracture that does not bear ore. Solution effects are visible, but they are not so important as in the northwest-trending orebodies; the tectonically formed structures therefore have not been greatly modified by solution in these east-trending bodies. This type of orebody may be as much as 2000 ft long, 250 ft wide, and 80 ft high, although the average orebody is about 1000 ft long, 125 ft wide, and 50 ft high.

Four examples of the application of geology to the finding of orebodies in this area are:

1) The area southeast of Shullsburg, Wis., had been unprospected because of its cover of Maquoketa strata, as mine operators thought that ore did not occur in areas where the ore zone was overlain by Maquoketa shale, and because the cover of shale necessitates deeper drilling. Success of the exploration program of Calumet & Hecla Inc.[39] in the area is due in large part to the combination of grid drill-

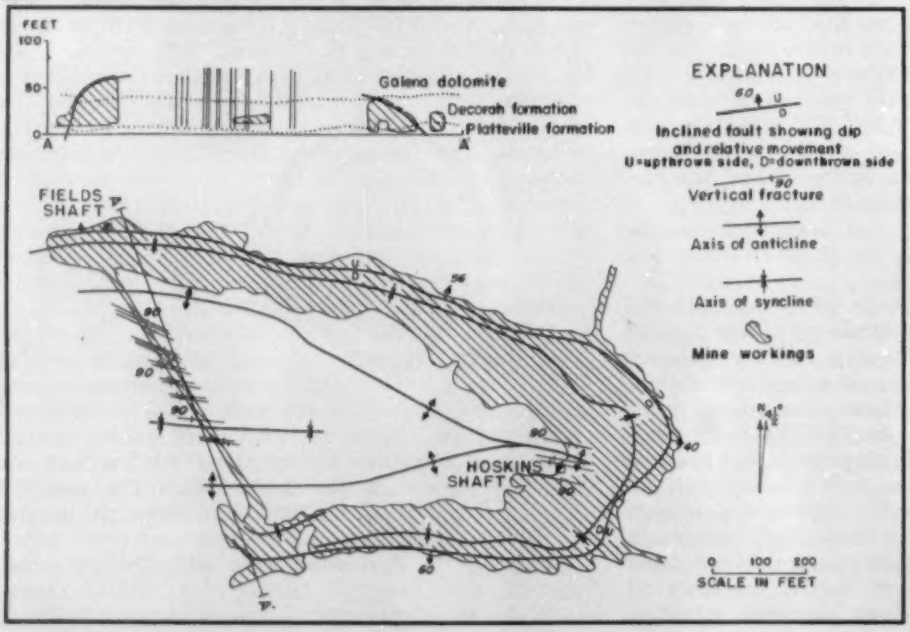

Fig. 9—Plan and cross-section of Hoskins mine, Wisconsin, showing horseshoe-shaped pitch wrapped around a broad fold. Geology by A. F. Agnew and A. V. Heyl, Jr., 1944.)

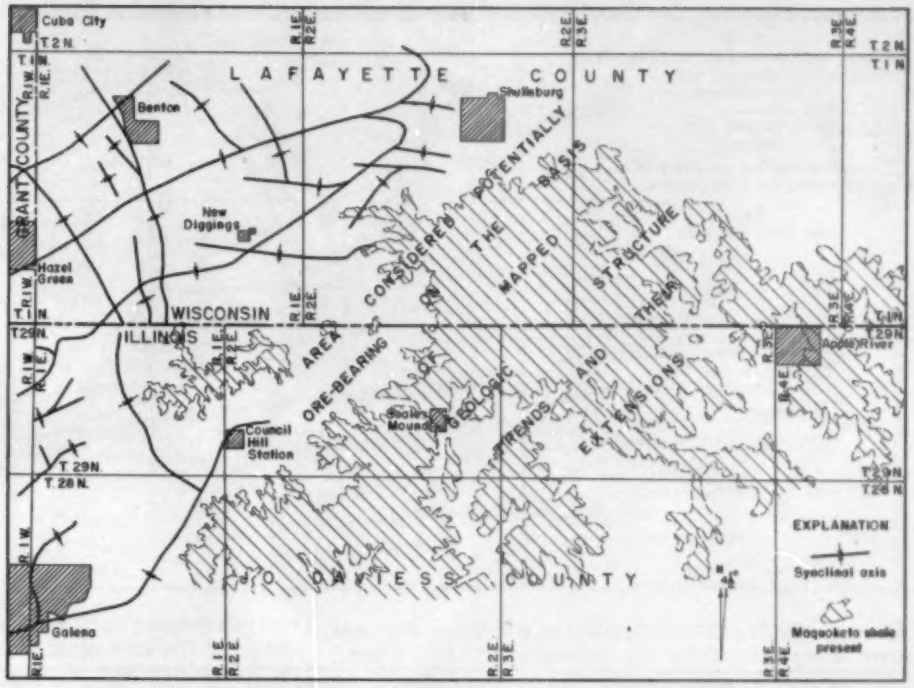

Fig. 10—Map of area including Galena, Ill., and Shullsburg, Wis., showing area covered by Maquoketa shale and general synclinal axes that could be projected eastward from the Hazel Green-Shullsburg area and northeastward from the Galena area. (From Agnew, Heyl, Behre, and Lyons[35]; Willman and Reynolds[36]; Shaw and Trowbridge[40]; and Grant and Burchard.[41])

ing methods and outcrop mapping. This company projected to the east and to the northeast the synclinal axes and ore trends shown, Figs. 7 and 10, by outcrop mapping.[35,36] Carrying out its grid drilling program on a prediction of the continuity of structural trends and a repetition of structural pattern, Calumet & Hecla was successful in locating several synclines, some of which contained orebodies now being mined.

2) In the northwest part of Sec. 21, T. 1 N, R. 1 E, the juncture of northeast-trending and northwest-trending synclines was mapped, Fig. 7, *A*. In this vicinity several small patches of ore have been drilled, and recently one of the mining companies discovered an orebody at the juncture which was not known before the structure mapping.

3) In the south-central part of Sec. 26, T. 1 N, R. 1 E, a syncline was mapped, Fig. 7, *B*, showing a bend toward the west. This syncline is the southwestward continuation of the general synclinal trace that extends northeastward for 5 miles and contains at least a dozen zinc-lead mines. Recently a mining company discovered an orebody at the bend in the southwesterly projection of this synclinal trace; the alignment of mines had previously been projected inaccurately because the bend in the syncline had not been recognized.

4) In the center of fractional Sec. 14, T. 29 N, R. 1 E, south of the state line, Fig. 7, *C*, an orebody was discovered in 1947 by one of the mining companies. This ore occurs along the southward projection of one of the mapped synclinal axes.

The outcrop mapping in the Potosi area,[37] Fig. 2, showed the two general trends of synclinal axes, east-southeastward and northeastward, see Fig. 11.

In the east-southeastward synclines zinc-lead orebodies have a similar strike. These orebodies are said[38] to be controlled by single-pitch and double-pitch faults. Outcrop geologic mapping showed a pitch zone along the limb of a fold in a ravine almost a mile to the east of these orebodies, and a westerly continuation of this fold was mapped.

Not long ago one of the mining companies discovered an orebody by drilling along this westerly projection. Active mining in the Potosi area has not been carried on for many years, and the discovery lends impetus to further development of that area.

Late in 1942, in the course of a cooperative exploratory venture with the USGS, the U. S. Bureau of Mines drilled the Gray property in Illinois, because several earlier drillholes had penetrated lean zinc-lead bearing material 40 to 50 ft thick, on an extension of the Black Jack-Pittsburg ore trace, Fig. 12. As a result of this drilling in 1943 the 479,500-ton[39] Gray orebody was discovered. Mining of the ore began late in 1944.

During the early months of drilling the Gray orebody, structure contours based on the drilling on this property and on old records from the Black Jack and the Pittsburg mines to the north, coupled with the discovery of a pitch-type fault in an exposure just north of the Pittsburg mine, showed that a syncline and associated pitches controlled the trend of the orebodies, Fig. 12. In May 1943, therefore, the USGS recommended that a line of five holes be drilled across the projection of this syncline and associated pitches about 2000 ft southeast of the Gray orebody. In the summer of 1943 the Illinois State Geological Survey mapped the outcrops in this area in detail, corroborated the presence of this syncline, and showed its regional setting.[39] In June 1944 the USBM penetrated the Bautsch orebody with the fourth hole of the proposed five-hole cross-section, and by 1945 the drilling had disclosed more than 916,500 tons of ore.[39] The Bautsch orebody was therefore found by drilling on the projection of a syncline and the accompanying pitch zones.

The above illustrations of ore discovery are cited as examples of the application of areal mapping of geologic structure. Many additional ore discoveries by mining company geologists are known.

Spacing of geologic data in great part governs the accuracy of any structural map. Thus, orebodies that lie between synclines shown by outcrop mapping or grid drilling would be overlooked by either of these methods. On the other hand, it should not be inferred that all synclines or all leached areas are ore-bearing. Many of the folds will be found to contain weak evidences of zinc-lead mineralization, or only iron minerals; others may show only the

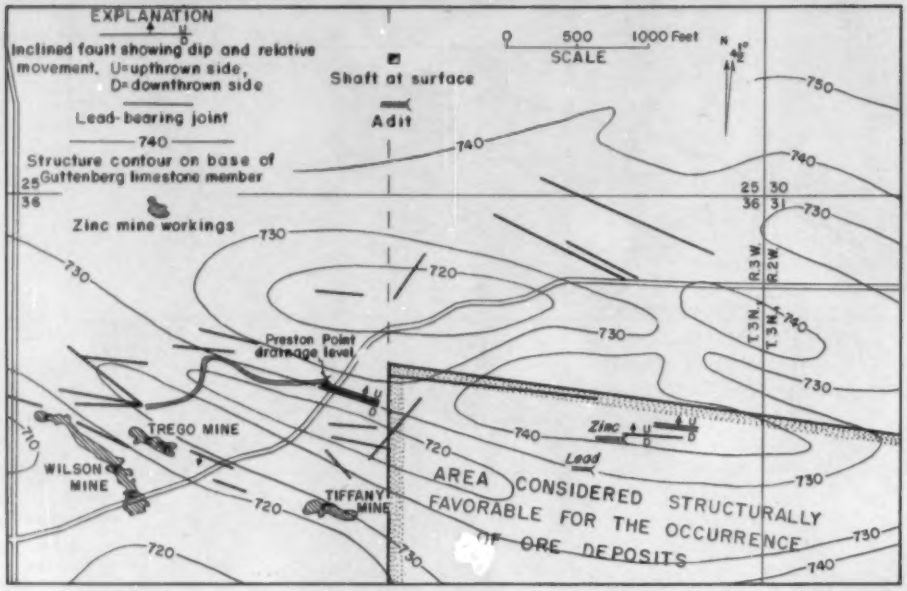

Fig. 11—Map of part of Potosi area, Wisconsin, showing structure trends, orebodies, and potentially ore-bearing area. (From Heyl, Lyons, and Agnew.[37])

leaching effects of the mineralizing solutions, whereas some folds may show no evidence of having been mineralized. The final answer is of course found by prospect drilling.

Structural generalizations are not necessarily valid in all areas. For example, it is common knowledge that north-south orebodies are very rare in the district, yet note the northerly trend of the New Hoskins-Cottingham No. 2 orebody (Fig. 7, *D*) which

Fig. 12—Map showing Black Jack mine workings, Pittsburg mine workings, Gray orebody, projected geologic structure, proposed and drilled initial cross-section of holes, and the resulting Bautsch orebody discovery, Illinois. (Data in part from Zinner and Lincoln.[40])

was extremely rich. Furthermore, the structural relations of the orebodies south of Shullsburg (Calumet & Hecla Inc. and Vinegar Hill Zinc Co. leases) are not completely known as yet; detailed study of the mines developed in this area may show additional geologic controls or modifications that can be applied in the potentially productive territory farther south and east. Nevertheless, the type of geologic mapping cited on the previous pages, if data are adequate, can rule out areas that are potentially unproductive, effecting a saving in prospecting cost.

Lastly, although all geologists do not agree fully on the source of the ores, or on the precise origin of the pitches, these considerations do not materially affect the use of the surface and subsurface manifestations and geometry of the geologic structure in prospecting.

Structure Mapping in the Mines: Miners can usually follow the ore without difficulty because the ore in most places is easily recognizable underground and the pitches are relatively smooth and continuous. On the other hand, a knowledge of the geology, together with detailed geologic mapping underground, has proved valuable in several places to locate ore shoots that otherwise would have been missed.

The Martin mine, Fig. 13, has developed a horseshoe-shaped orebody in a northeast-trending syncline, Fig. 7, *E*. The orebody is controlled by a north-northeast-directed horseshoe-shaped single-pitch zone.

Mining was proceeding in late 1943 near the south end of the west limb of the orebody easterly toward some drillholes that showed lean ore. The geologic map of the mine prepared at that time indicated that the ore found in these holes was part of a north-northeast-directed core ground[39] body that would continue at least to the end of the crosscut 400 ft to the north, where a drift driven easterly from the shaft had intersected vertical fractures that contained breccia zinc ore; drillholes showed this core ground ore to continue 200 ft beyond the drift. As a result of this geologic mapping the mining company did not cease its operations in this mine, but continued mining the ore in this core ground for 2½ years.

Along the northwest and north side of the orebody the geologic mapping showed several places

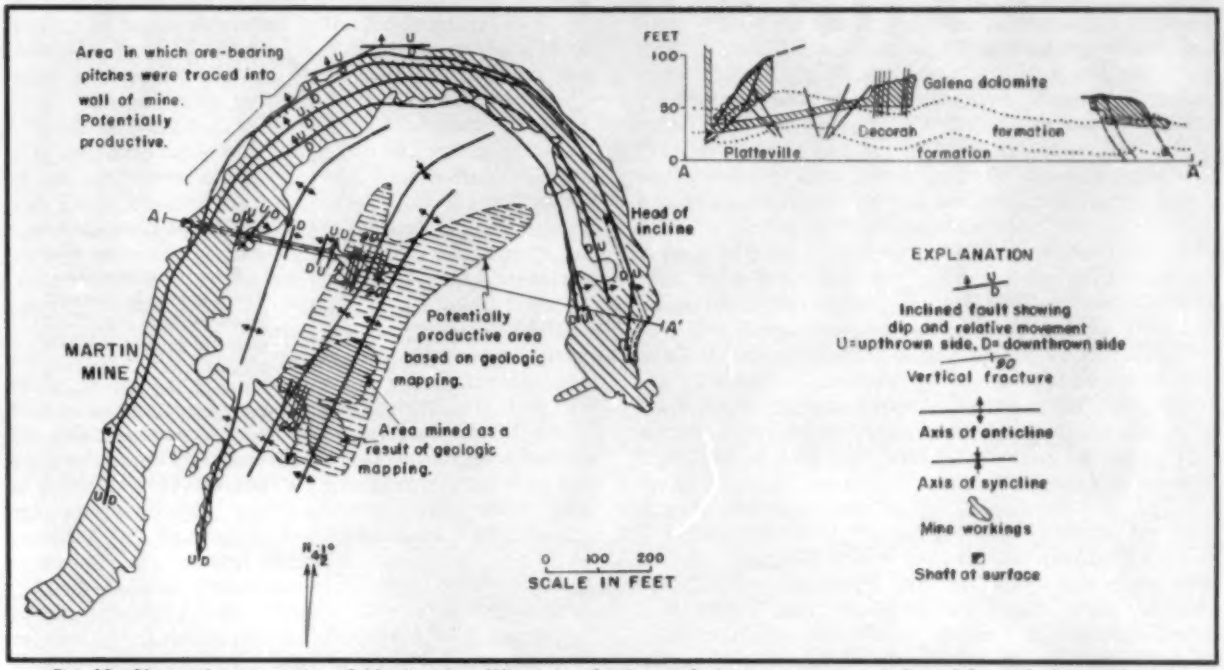

Fig. 13—Plan and cross-section of Martin mine, Wisconsin, showing geologic structure, areas indicated by geologic mapping as potentially productive, and area subsequently mined. (Geology by A. V. Heyl, Jr., A. F. Agnew, C. H. Behre, Jr., and E. T. McKnight, 1943.)

where pitches were traced into the outside wall of the stope; their traces were discovered again in the stoped area, 100 to 200 ft farther along the wall. This suggested that additional ore could be obtained by mining the intervening area.

The Graham-Ginte mine, Fig. 8, is in an elongate northwest-trending double-pitch orebody, controlled by a gentle northwest-trending syncline that has a well-developed central anticline broken by steep normal faults. In 1944 mining was progressing southward from the old Graham mine along drilled-out ore. Geologic mapping by the USGS showed that at the south end of the Graham mine an arcuate pitch connected the east and west pitches at their lower level (Guttenberg and lower part of Ion beds), where an east-trending syncline crossed the north-trending structure. Geologic interpretation suggested that this pitch connected the east and west pitches at higher levels as well, thus forming an inverted spoon-shaped pitch that would be continuous upward until the *top flat* was reached. On the basis of this interpretation the mining company drilled five holes in the core ground area, which was considered barren from evidence in the stopes along the east and west pitches; these holes corroborated the geologic interpretation, and thousands of tons of ore thus found in the core ground area were mined during the next two years.

Interpretation of the geologic map also suggested that south of the cross-syncline the east pitch diverged eastward; this suggests that it might be profitable to prospect east of the southern extension of the mine workings, which are along the west pitch zone and in the core ground.

The Liberty mine, Fig. 14, was developed in an east-trending horseshoe-shaped single-pitch body. Geologic mapping showed that during mining the main pitch had been lost in an area from 200 to 400 ft along strike east of the shaft. On the basis of the geologic mapping a 40-ft cross-drift was driven to

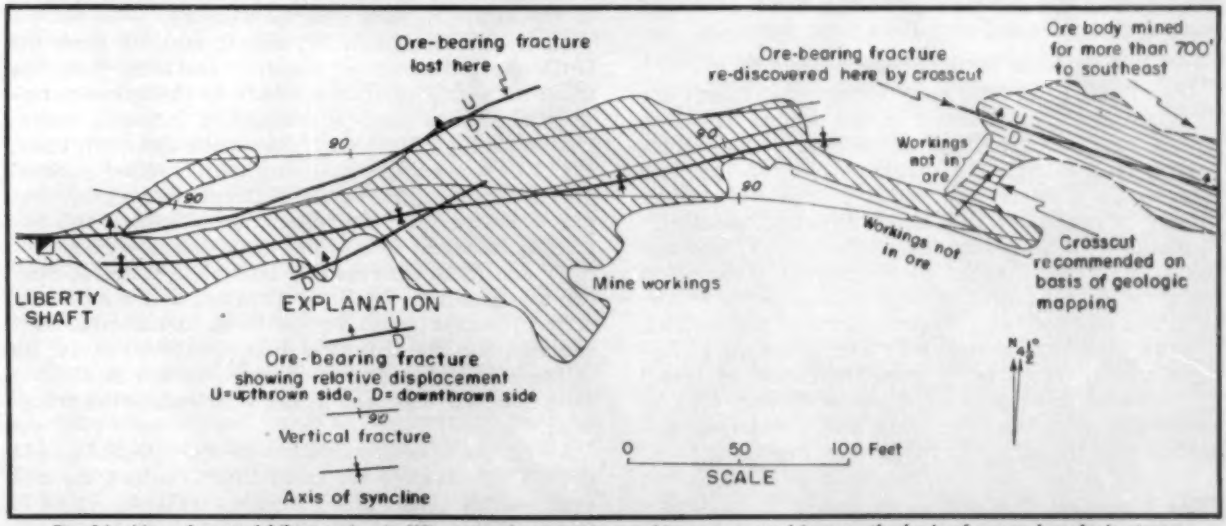

Fig. 14—Map of part of Liberty mine in Wisconsin showing mine workings, crosscut driven on the basis of mapped geologic structure, and part of the orebody discovered as a result. (Geology by A. F. Agnew, A. V. Heyl, Jr., and C. H. Behre, Jr., 1943-1944.)

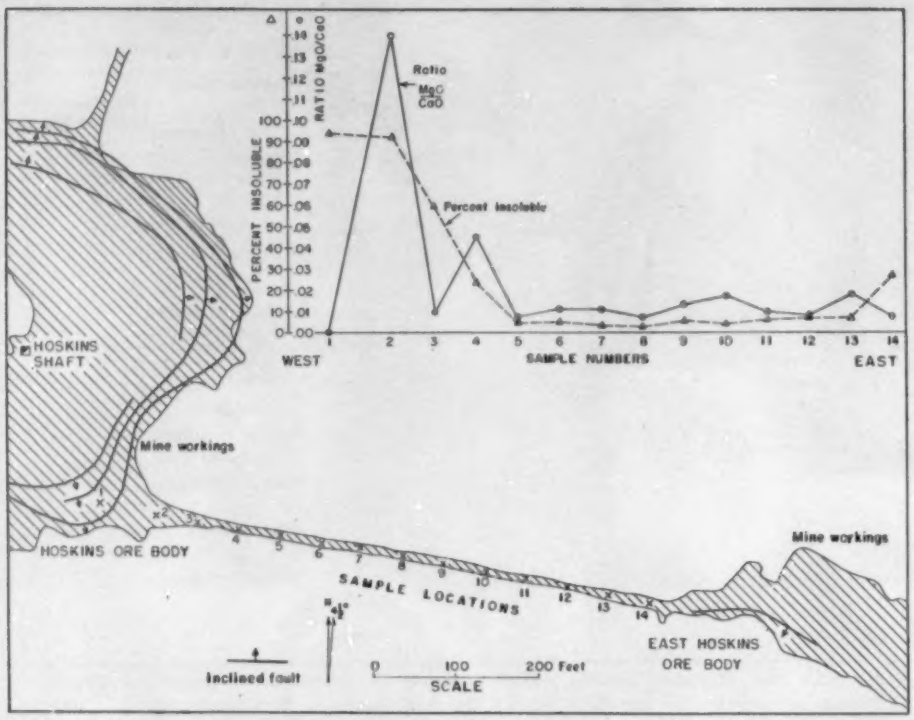

Fig. 15—Map of part of east end of Hoskins mine in Wisconsin showing locations sampled in crosscut. Graph indicates MgO/CaO ratio and percent insoluble material in Guttenberg limestone member. (Geology by A. F. Agnew and A. V. Heyl, Jr., 1944. Analyses by Marie L. Lindberg, USGS, Feb. 13, 1945.)

the north, the pitch zone was rediscovered and was then followed for 700 ft to the east, and the ore thus found was mined during the next two years.

In the Wisconsin-Illinois-Iowa zinc-lead district some of the ore potentialities of mines are missed as mining proceeds. Detailed geologic mapping underground by the USGS during World War II was of value in discovering ore shoots and in noting the economic potentialities of fractures that were neglected as probably unproductive; it is suggested that mining companies may find it profitable to have their geologists do similar mapping.

Recently block caving was introduced into this district. Where this method is used, parts of the faces of the stopes are inaccessible unless geologic mapping is continued each day as mining advances. Together with the height of the open stope (up to 125 ft) and the haze caused by the humidity,‡ this makes accurate geologic mapping difficult. Nevertheless, geologic staffs can contribute to economic mining of the ore and should do stope mapping.

‡ Most of the large mines pump 2000 to 3000 gal of water per min.

Crevice or Vertical Fissure Deposits

Owen[8] cited the following "symptoms of lead ore in Wisconsin": 1) A bench in the outline of a hill. 2) "A small longitudinal depression, or miniature ravine, on a hillside." 3) Sinkholes "in an east and west or in a north and south course." 4) "Rank growth of vegetation in a linear direction, especially of plants with deep-reaching radicals." 5) "Red appearance of the surface." 6) Fragments of calcite at the surface. (If found in large quantities, however, as in the southern and western parts of the district, it is an unfavorable sign.) 7) The presence of *Receptaculites*, which is "a good indication of lead." 8) " 'Gravel mineral' (small pieces of lead ore) in connection with the crumbling and arenaceous appearance of the adjacent magnesian limestone."

Daniels[9] noted that "in the vicinity of veins the rocks are often so changed, as nearly to obliterate their usual characters." Percival[4] was more specific when he wrote that the rock which is now called the Guttenberg member is much decomposed for 6 to 8 ft on each side of a vertical crevice, with normal fossiliferous limestone beyond.

Some of the symptoms of Owen, with additions, are still used by prospectors and by the USGS in outcrop mapping. Sinkholes, vegetation marking traces of joints, and ocher red streaks in the surface material are all useful criteria.

Other Applications of Geology

Other applications of geologic knowledge and techniques to the discovery of ore deposits have been attempted. Some of the significant ones, or those that appear to show promise, are cited below.

Geochemical Prospecting: In 1943 and 1944 mapping by the USGS disclosed halos of SiO_2 and MgO in the Guttenberg and Quimbys Mill members around several orebodies, especially the east-trending horseshoe-shaped single-pitch type. These halos were detected in the field by the hammer and acid bottle. The presence of the halos suggested that chemical analysis of the rock might be revealing, as the following four examples show.

1) In the Hoskins mine, Fig. 9, samples from the Guttenberg member in the drift eastward from the main horseshoe-shaped orebody to the eastern orebody showed a high percentage of insoluble material and a high MgO/CaO ratio near the main body, Fig. 15. As geologic mapping underground showed only slight leaching of the Guttenberg member but did illustrate that the rock was silicified, the insoluble material is believed to be mainly SiO_2.

2) A similar increase in insoluble material near ore was noted in the B. A. T. mine, half a mile east of the Hoskins mine. In the B. A. T. mine the unit sampled was the Quimbys Mill member, Fig. 16. As in the Hoskins mine, an increase in the MgO/CaO ratio near ore was seen at the west end of the crosscut drift.

3) At the recommendation of the USGS in 1944 the USBM sampled for magnesium content the soil over part of Coker No. 1 orebody (Fig. 3, *A*) 80 ft below the surface. Analysis of the soil samples showed an increase in the MgO content above the

ore.[28] This increase of MgO over the orebody is even more significant than that in the Hoskins and B. A. T. mines because the underlying bedrock at the Coker mine is dolomite rather than limestone. Thus the dolomitization here had affected dolomitic rocks.

4) In at least two localities in Wisconsin, halos of lead and zinc have been found in soil samples taken above zinc-lead orebodies. At the Porter's Grove and Crow Branch diggings (Fig. 3, *B, C*) soil samples taken by the USGS showed high zinc and lead values across the projection of the alignment of mineralized areas where the zinc and lead minerals are first found as much as 150 ft below surface.[28, 29]

The geochemical indications described above appear significant enough to warrant further research along these lines. Analyses for heavy metals and MgO/CaO ratio are particularly promising and can be determined by microchemical analysis of drill-hole cuttings from so-called barren holes (barren of zinc-lead and even of iron minerals), from cross-cuts underground, and also from analysis of soil samples. In essence, the geochemical methods increase the size of the target.

Geobotanical Prospecting: Owen[8] observed that "rank growth of vegetation in a linear direction, especially of plants with deep-reaching radicals," was a "symptom" of lead ore. This concept was reiterated by Daniels,[9] who noted that "a certain plant, known as the 'masonic' or 'lead weed,' grows only where its roots are fed by lead ore," and he stated that roots of this plant are often found 40 to 60 ft below the surface. Daniels reports that this indication seems to have been learned from Indians.

Recent observations in this district have shown that some old lead pits are marked by the *Indian leadweed* (large-bracted wild indigo), which has a large root. Cottonwoods, and in some places white birches, are characteristically found either in pits or on waste piles of old lead and zinc diggings; the greater acidity in the soil is probably responsible, in part, together with the characteristic deep root growth of these trees.

Geophysical Prospecting: In 1923 a method using "spontaneous polarization" was applied in the Shullsburg, Wis., and the Galena, Ill., areas, see Fig. 2, in an attempt to discover ore. In 1928 self-potential, applied potential, and magnetometer surveys were all made in the Linden and Dodgeville areas of Wisconsin. Not until the middle 1940's, however, was any concerted attempt made to experiment with geophysical methods in the hope of establishing controls that could be employed economically as guides to ore.

Since that time several private companies, the Illinois State Geological Survey, the USGS, and the Geological Society of America, have supported surveys by one or more methods, which have been applied locally in the search for specific orebodies. Methods that have been tested include self-potential and induced-potential, resistivity, electromagnetic, gravity, seismic, radioactivity, and geothermal. Some of these methods have shown promise, but insufficient testing has been done, and the results of most of the surveys have not been released for publication. An integrated program of research in geophysical methods might provide conclusive data regarding the economic value of one or more methods.

A preliminary aerial magnetometer survey has been made by the USGS over part of the mining district, but results have not yet been published. It is believed that such a survey would give information relative to the general topography of the surface of the pre-Cambrian rocks but would not show such relatively small features as the folds controlling the individual zinc-lead orebodies, which are some 1500 ft above the pre-Cambrian surface.

Lower Potentially Productive Zones: Daniels[9] noted that the veins in the Galena dolomite are not present in the underlying "blue limestone" (Guttenberg member and lower part of the Ion member) but "resume again in the buff-colored rock" (*glass rock*, or Quimbys Mill member).

In 1894 Blake[26] withdrew attention from the glass rock as a potential ore host, for he held that the downward-percolating waters that carried the lead and zinc were stopped at the "impervious layers of shale or clay [Spechts Ferry member] at the top of the Trenton limestone." He continued with the statement that ore deposits in the glass rock are in places from which the overlying Galena dolomite has been largely removed by erosion, implying that these deposits are secondary and should not be considered characteristic of the glass rock.

Behre[27] revived the glass rock question by reiterating Grant's[30] views that in the northern part of the district the ore is largely below the glass rock and noted that "mineralized faults cross the 'oil rock' and Spechts Ferry shales." These statements were an attempt to dispel the belief then held by many geologists that the ores, thought to be deposited from descending waters, had been dammed above the glass rock.

Although some mining men knew of mines that had been developed in glass-rock strata, prospecting and mining of these beds in the early 1940's was not systematic; this was due partly to the additional water that they knew would be encountered during mining in these beds. Geologists stressed that zinc-lead production could come from these beds, particularly below strong pitch-zone ore. As a result several mines were deepened to work ore in the glass-rock unit, and a few were developed solely to work glass-rock ore. At one period during World War II one-seventh of the production of this district came from ore in the glass rock.

Since that time prospecting the glass rock has been standard procedure with most operators, and many of the current mine operations are being conducted in orebodies in the glass rock.

Grant[31] noted that at the Little Giant mine (Fig. 7, *F*) ore similar to that in the glass rock had been intersected in a shaft for a distance of 22 ft below the base of the glass rock. This ore, the stratigraphic sequence tells us, occurred in the so-called *Trenton* beds, or McGregor member. As the McGregor strata are argillaceous nodular limestones similar to the Guttenberg and Quimbys Mill members, these strata were recommended by geologists in the 1940's as possible ore hosts in other areas. During World War II ore was mined from the McGregor member as much as 15 and 22 ft below the base of the glass rock, a mile north and a mile south of the Little Giant mine, respectively. Ore in these beds in the areas south of Shullsburg, south of New Diggings, and south of Galena has been intersected by recent drilling. Current prospecting technique includes drilling into McGregor strata in areas that appear favorable because of indications in overlying rocks.

Owen[8] suggested that the *Lower Magnesian* (Prairie du Chien) limestone, if extensive north of the Wisconsin River, "may there yield veins of lead ore." Galena has been mined from these Prairie du Chien strata at several localities north of the district, see Fig. 3. Recent drilling by the USGS[28, 29] has

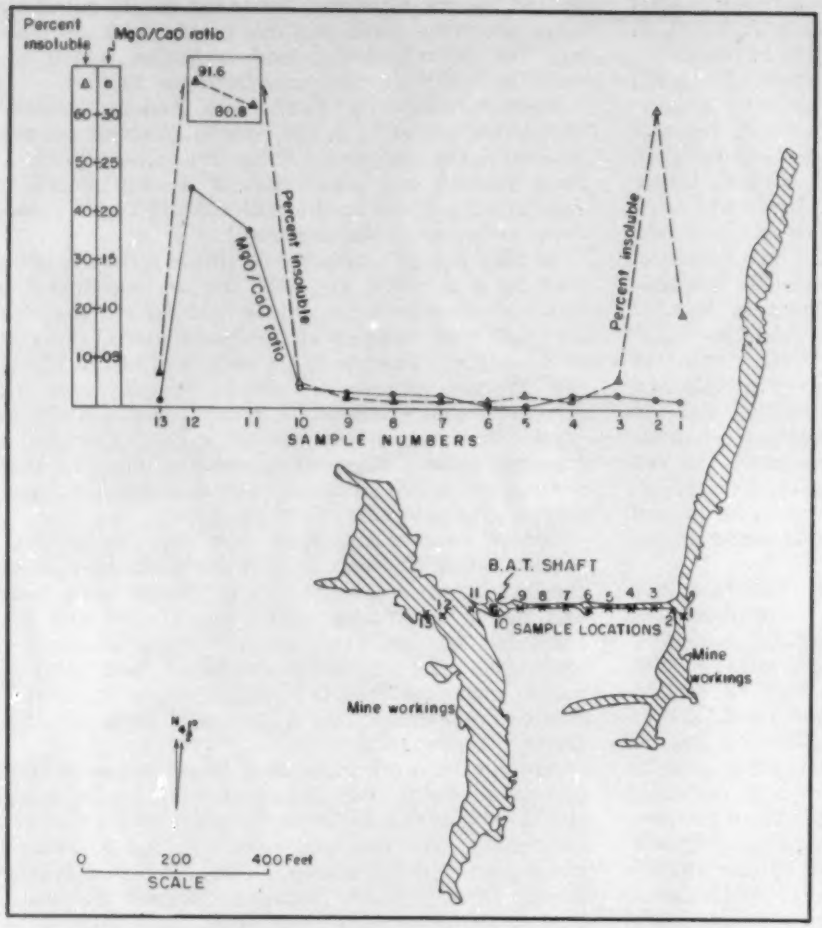

Fig. 16—Map of B. A. T. mine, Wisconsin, showing locations sampled in crosscut. Graph indicates MgO/CaO ratio and percent insoluble material in Quimbys Mill member. (Geology by A. F. Agnew, A. V. Heyl, Jr., and C. H. Behre, Jr., 1943. Analysis by Marie L. Lindberg, USGS, Feb. 13, 1945.)

shown that at least three zones of mineralized rock exist in this stratigraphic unit. The dolomite and cherty dolomite of the Prairie du Chien are extremely tough, and the cost of breaking this rock during mining operations might be high. Furthermore, the unit is characterized by rapid lateral and vertical facies changes from dolomite to red and green shales and sandstone, and this, together with the disconformable relationship between the Prairie du Chien and the overlying St. Peter sandstone, makes the type of lithology to be expected in even a local area uncertain. As a result many areas will be unproductive at the Prairie du Chien stratigraphic position because of unfavorable rock type. The dolomite of the Prairie du Chien does constitute a possibly productive lower zone, nevertheless, and its potentialities should be explored further.

Mining: Owen noted[8] that the lead shafts were usually abandoned as soon as they reached or penetrated a short distance below the static water level. Even today this fact is mentioned by the old-timers, so it is logical to assume that water has been a factor in prospecting since Owen's time. Potential lead-zinc ore still exists below the lowest workings in many of the crevice mines. Furthermore, zinc-lead ore remains below the floor of some of the pitch-and-flat mines, as was shown during World War II when many orebodies were re-entered and the ore below the floor was taken out.

As was mentioned earlier, p. 785, because of the southward regional dip and consequent increase in the height that water must be pumped, orebodies in the southern part of the mining district and to the south and southwest will contribute more water than those to the north; 2500 gpm is not uncommon in the south, whereas 500 gpm or less is all that need be pumped from mines in the northern part of the district.

Whitney, recognizing the stratigraphic correlation of the openings in the Dubuque area, recommended that "horizontal drifts or excavations are the proper means of exploration, and not vertical ones or shafts."[9] Such drifts or levels, he reasoned, would prospect several crevices at an opening zone and would also provide gravity drainage for the water. He later extended this recommendation to the mines in Wisconsin,[10] citing in the Shullsburg area a level that had been so opened and had drained water from numerous crevices.

Since Whitney's time several mines in many parts of the district have been opened in this way, both in crevice orebodies and in pitch-and-flat orebodies, and water has been drained and ore trammed to the surface by gravity. These orebodies could not have been mined economically otherwise.

Calvin and Bain[21] agreed with Whitney that a series of crevices could be worked as one development by crosscuts at the levels of the openings, but they applied this suggestion to areas where topography would require a shaft, which they recommended be centrally located. They suggested further that raises be put up to mine upper openings.

During recent years this method has been successfully applied to the pitch-and-flat orebodies by several companies. Its application to crevice deposits might be a means of extracting bodies of lead or zinc that can not be mined economically otherwise.

Conclusions

Cooperative geological investigations by the USGS, the Wisconsin Geological and Natural History Survey, and the Iowa Geological Survey, together with studies by the Illinois State Geological Survey, have shown that detailed stratigraphic work and detailed mapping of geologic structure have been important factors in the renewal of interest in the Wisconsin-Illinois-Iowa zinc-lead district. Certain facets of the geologic methods discussed in this paper had their origins in earlier surveys of this district, and after a period of disuse or even discredit, these ideas have been revived and are currently factors in the economic potential of the district.

Detailed mapping of stratigraphy and structure has revealed the following: 1) Pitch-and-flat orebodies are controlled by fracture zones along small folds arranged along larger folds. 2) Using the detailed stratigraphic units established by this cooperative study, these folds and faults can be mapped from outcrops and supplemental drillholes. 3) Detailed geologic mapping underground can help prevent losing ore shoots and misinterpretation of quirks of the orebodies. 4) Geochemical techniques show promise, especially heavy metals and MgO/CaO analysis.

Applied geology has given this district an important tool for distinguishing areas of more promise from less promising ones. As a result 1) the amount of ineffectual prospecting in potentially unproductive areas (structurally) has been decreased, 2) the amount of ineffectual prospecting and development in potentially productive areas has been decreased, and 3) the effectiveness of mining of individual orebodies and parts of orebodies has been increased. Furthermore, the recognition of geologic controls and the application of this knowledge to the discovery of orebodies in recent years has attracted large companies (with geologists) to this district, which had long been considered mined out.

Acknowledgments

The current USGS project was motivated by C. H. Behre, Jr., then at Northwestern University, who since 1933 had been supervising studies in this district by his students and had recognized the potential value of a thorough geologic study of the structure of the ore deposits. Allen V. Heyl, Jr., of the USGS, and the author mapped the mines cited in this paper and discussed many of the concepts presented. Paul Herbert, Jr., now with Tri-State Zinc Inc., has made numerous contributions to the knowledge of stratigraphy of the district. R. R. Reynolds, of Calumet & Hecla Inc., and H. B. Willman, of the Illinois State Geological Survey, contributed to the knowledge of the structure and stratigraphy of the Illinois part of the district. Representatives of mining companies, especially the Vinegar Hill Zinc Co., The New Jersey Zinc Co., and the American Zinc, Lead and Smelting Co., generously allowed the USGS access to their drilling and mining records. These data, as well as the information and counsel given by C. W. Stoops, were of great assistance. Water-well and prospect-hole drillers and mine operators supplied useful records.

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Technical Note

A Stereographic Method of Determining the Attitude of Beds Intersected by Diamond Drilling

by J. W. Mills

THE strike and dip of bedded formations is readily determined by trigonometry if some marker horizon is intercepted by three holes. If no marker can be identified and if orientation of the cores is unknown, as is the usual case in diamond drilling, the determination still can be made readily by the use of a stereonet if the bearing, inclination, and angle the bedding makes with the core axis is known for each of the three holes. Such determination, valid only if the bedding orientation is fairly uniform within the area drilled, is considered simpler, faster, and more effective than any solution previously published.

Method: The steps of this procedure are as follows:

1) Mark north and south poles on tracing paper placed over stereonet.*

* Standard meridional nets, printed on heavy white cardboard, may be purchased from the University of Chicago bookstore.

2) Plot the three diamond drillholes by drawing a line from the center of the net in the direction of the bearings of the holes. Then rotate the paper until each line, in turn, lies along the equatorial diameter of the net; the end of each line is determined by the inclination of the hole measured in degrees from the periphery toward the center of the net along the equatorial diameter. Fig. 1 illustrates a vertical hole and a hole inclined at −23° due east.

3) With the projection of one diamond drillhole along the equatorial diameter, measure from the end of the hole, to the east and then to the west, a distance in degrees equal to the core axis-bedding plane angle. Find two more points by measuring the same number of degrees north then south along the great circle from the end of the drillhole. Draw a circle, the center somewhere along the direction of the projection of the drillhole, to connect these four points. Draw circles for the other two diamond drillholes in the same manner. See Fig. 1 for two circles representing core axis-bedding plane angles of 35° and 23° and Fig. 2 for these plus a third circle representing a core axis-bedding angle of 42° in a hole bearing S 50 W inclined at −52°.

4) Rotate the tracing paper until one great circle on the stereonet is found which is tangent to all three of the circles or parts of circles derived in the previous step. Trace this great circle on the paper and join its ends with a straight line passing through the center of the net. The bearing of this line is the strike of the bedding. In Fig. 2 the bedding strikes N 77 E.

5) Rotate the paper until the strike is along the polar diameter of the net. The dip of the bedding is determined by measuring along the equatorial diameter the distance in degrees from the periphery of the net to the great circle derived in step 4. The dip of plane illustrated in Fig. 2 is 55° to the N 13 W.

Fig. 3 indicates the solution for three holes whose bearings and inclinations are N 20 W and −43°, due E and −30°, S 30 W and 23° with core axis-bedding angles of 30°, 50°, and 43° respectively. The bedding (stippled area) strikes N 44 W and dips 70° to the southwest.

J. W. MILLS, Member AIME, is Assistant Professor and Acting Chairman, Dept. of Geology, State College of Washington, Pullman, Wash. Manuscript, Nov. 8, 1954. TN 264 I.

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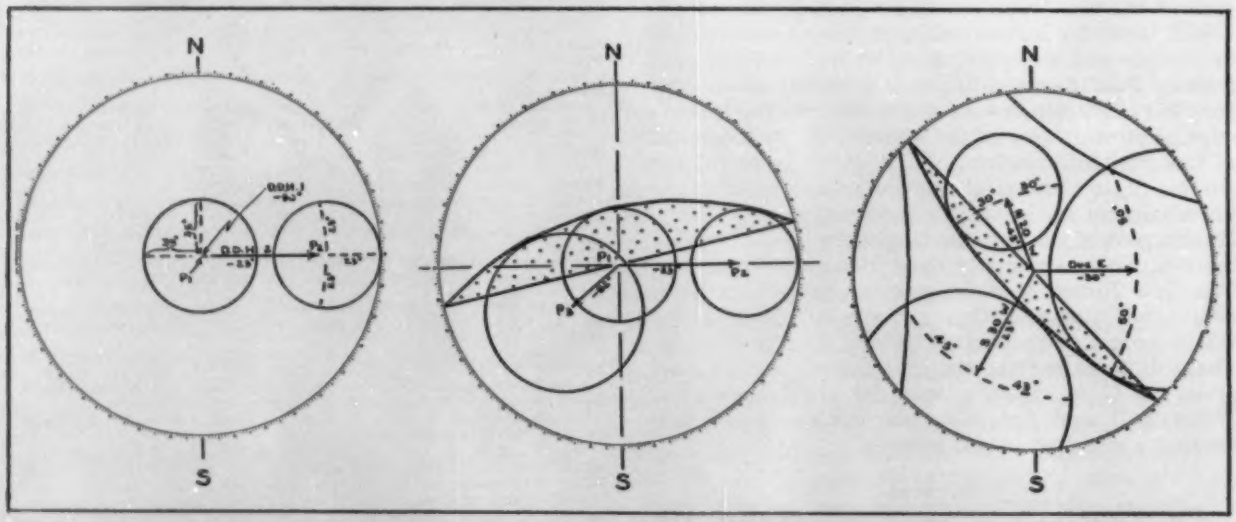


Fig. 1 (left)—Vertical hole and hole inclined 23° due east. Fig. 2 (center)—Additional third hole representing a core axis-bedding angle of 42° in hole bearing S 50 W inclined at −52°. Bedding strikes N 77 E. Fig. 3 (right)—Solution for three holes whose bearings and inclinations are N 20 W and −43°, due E and −30°, S 30 W and −23° with core axis-bedding angles of 30°, 50°, and 43° respectively. The bedding (stippled area) strikes N 44 W and dips 70° to the southwest.

aime news

Second Annual Rocky Mountain Minerals Conference

The Second Annual Rocky Mountain Minerals Conference will take place in Salt Lake City October 6 to 8 with the Utah Section of AIME as host. The Minerals Beneficiation Div., holding its fall meeting simultaneously, is represented by a generous number of milling papers distributed through the 3-day meeting, and by its traditional Scotch Breakfast and MBD Luncheon. An innovation in this Conference is the absence of simultaneous sessions. Each of the five sessions will cover a wide range of professional interest.

Registration will start Wednesday afternoon, October 5, and technical sessions will be held morning and afternoon on Thursday and Friday and on Saturday morning. Seven field trips are planned for Saturday afternoon. Special cars on the Las Vegas train will be supplied on Sunday morning for those who want to attend the American Mining Congress Meeting in Las Vegas, Nev., starting Monday, October 10.

The Rocky Mountain Conference of last October was sponsored by the Industrial Minerals Div., and the interest was such that it has now broadened this year to include the whole Mining Branch and the Metals Branch. Other sections besides Utah have signified a desire to play host, and it appears likely that this Rocky Mountain Minerals Conference will become a permanent institution. This year's program at Salt Lake City includes papers on geology, mining, minerals beneficiation, extractive metallurgy, and education. Commodity-wise, there are papers on uranium, coal, iron and steel, industrial minerals, base metals, tungsten, and rare metals. *(Program of Technical Sessions and list of field trips appears on page 798.)*

Officers of the Utah Section, host for the conference, are Jack M. Ehrhorn, Chairman, and Neil Plummer, Vice Chairman. Responsible for conference arrangements are Norman Weiss and R. C. Cole, general co-chairmen. Mrs. Max Kennard, Chairman of the Women's Auxiliary AIME, Utah Section, will supervise the arrangements for the ladies' activities.

One of the field trips will visit the Geneva steel works.

The city has a number of fine golf courses which should be in top condition in early October. Besides the private 18-hole courses at Fort Douglas and the Country Club, there are three 9-hole and one 18-hole municipal courses. Enthusiasts will have no trouble finding all the golf they want.

Salt Lake City shops and department stores are sure to claim part of the ladies' time, but coffee at the Newhouse from 9 to 11 am on Thursday, and Luncheon and Fashion Show on Friday are also planned for them. Ladies are invited to attend the two luncheons, and the Scotch Breakfast. There will also be the Thursday evening cocktail party and the Saturday night dinner-dance.

Of first importance is the well-balanced technical program comprising 16 papers and a symposium. On Thursday noon Governor J. Bracken Lee of Utah will be guest of honor at the Welcoming Luncheon, and on the following day MBD will hear William W. Mein, Jr., Vice President and Director of the Institute at its regular fall luncheon. All attendance records may be broken when the pipers officially open the Scotch Breakfast, long an MBD tradition, at 7:30 am Saturday.

And not the least of the attractions of the Conference—for those who will go on to Las Vegas for the Mining Congress meeting—will be the enjoyable daylight train trip.

Reservations and Registration

Envelopes containing program, preregistration form, application for housing, and return envelope will be mailed about August 20 to all Metals Branch and Mining Branch members of the 11 Western States, Minnesota and South Dakota, and to MBD members in all states. Prompt replies are requested by the Committee.

Calendar of Events

(All events at Hotel Newhouse unless otherwise specified)

Wednesday, October 5
- 1 to 5 pm—Registration

Thursday, October 6
- 9:00 am to 12:00 m—Technical Sessions, see page 798
- 12:30 to 2:00 pm—Welcoming Luncheon—Guest Speaker: Hon. J. Bracken Lee, Governor of Utah
- 2:30 to 5:00 pm—Technical Sessions
- 7:00 pm—Cocktail-Buffet Party

Friday, October 7
- 9:00 am to 12:00 m—Technical Sessions
- 12:30 to 2:00 pm—Minerals Beneficiation Div. Luncheon—Guest Speaker: William W. Mein, Jr., Vice President and Director, AIME
- 2:30 to 5:00 pm—Technical Sessions
- Evening—Open

Saturday, October 8
- 7:30 am to 9:00 am—Scotch Breakfast as served by the Honorary Chefs of the Minerals Beneficiation Div.
- 9:00 am to 12:00 m—Symposium
- Afternoon—Field Trips
- 6:30 pm—Cocktails and Dinner Dance (Informal)

Sunday, October 9
- Train to Las Vegas 9:05 am Union Station, arrives 3:35 pm

Industrial Minerals Div. Fall Meeting at Charlotte, N. C.

With their fall meeting scheduled for October 27 to 29 at Charlotte, N. C., Industrial Minerals Div. members turn to the Southeast this year. Plans and program are rapidly falling into place for a 3-day meeting that will combine technical session and an afternoon of field trips.

The program is designed to emphasize three things: the economic geology of the Appalachian area; various aspects of quality control in the nonmetallic mineral industry; and new developments, the *avant garde*, of mining, milling, and exploration techniques.

Sessions will be held in the Hotel Charlotte and a round of social and entertainment events are being organized. Visitors to Charlotte at that time of year can normally count on beautiful weather.

Formal part of the program will start Thursday afternoon with three or four papers on the geology of the Appalachian area. Two already listed include a study of the relation of Appalachian geology to nonmetallic ore deposits by Byron Cooper, and another on water resources of the area by Harry LeGrande. Papers the second day have a central theme of quality control as applied to the industrial minerals industry. One paper by an author with Longyear Diamond Drilling Co. will consider exploration and prospecting of deposits as a quality control measure. Other papers in the quality control sessions as now planned include one on the mica industry by Ralph Adair, one on kyanite by C. Beers, a discussion of quality control in the heavy mineral industry by Frank McKinley, and another on quality control in the feldspar industry.

Saturday morning will feature a paper covering spodumene mining to be presented by E. Goter of Foote Mineral Co. It is planned to devote the rest of this morning session to a discussion of the most advanced techniques, equipment and concepts in the mining of minerals.

Field Trips Are Scheduled

One double field trip will take its group from Charlotte to Kings Mountain, N. C., for a look at the mining operations of Foote Mineral Co. From there the party will go about 6 miles to the kyanite operations of Commercialores Inc. at Clover, S. C.

Two other field trips are now scheduled. These will be a trip to a stone preparation plant and a visit to a scrap mica plant in the same area.

Rocky Mountain Minerals Conference:

Technical Sessions and Field Trips

Thursday am, October 6

Uranium Occurrences West of the Colorado Plateau. By Ernest E. Thurlow, manager, Salt Lake Exploration Branch, AEC.

Geneva Works Water Supply and Water Treating System. By Earl H. Pierce, power and fuel engineer, Columbia-Geneva Steel Div., U. S. Steel Corp.

Control Engineering in Minerals Beneficiation. By Carl M. Marquardt, Industrial Physics & Electronics Co., Salt Lake City.

Chemical Refining of Tungsten. Blair Burwell, Jr., Salt Lake Tungsten Co., Salt Lake City.

Thursday pm, October 6

Rare Metals. By M. H. Kline, vice president, Rare Metals Corp. of America, Salt Lake City.

Production of Phosphoric Acid and High Strength Phosphate Fertilizers from Western Phosphate Rock. By R. J. McNally, asst. manager, sulphuric acid dept., American Smelting & Refining Co., Salt Lake City.

Quantitative Approach to Bulk Material Handling Problems. By Andrew W. Jenike, consulting engineer, Salt Lake City.

Rod Mills and Ball Mills at the Hayden Plant of Kennecott Copper Corporation. By milling staff, Kennecott Copper Corp., Hayden, Ariz.

Friday am, October 7

Beneficiation of Utex Ores. By Clement K. Chase, chief metallurgist, Utex Exploration Co., Moab, Utah.

Underground Mining of Phosphates. By D. L. King, general manager, San Francisco Chemical Co., Montpelier, Idaho.

Forty-two Inch Vibrating Rod and Ball Mills. By F. E. Briber, Jr.

Engineering Education in the Mineral Industry. By John R. Lewis, head, Dept. of Metallurgical Engineering, University of Utah, Salt Lake City.

Friday pm, October 7

Award Paper—University of Utah student, winner to be announced later.

Uranium Mining Methods. By J. Fred Johnson, consulting engineer, Salt Lake City.

Approaches to the Problem of Coking Western Coals. By John D. Price, superintendent of by-product coke plant, Colorado Fuel & Iron Co., Pueblo, Colo.

Crushing and Milling at Pend Oreille East Mill. By J. C. Crampton, mill superintendent, Pend Oreille Mines & Metals, Metaline Falls, Wash.

Saturday am, October 8

Symposium—"Greater Cooperation Among Geologists, Mining Engineering, and Metallurgists for Metallurgical Planning"

W. R. Landwehr—Moderator
M. B. Kildale and Kenyon Richard, Geologists
A. G. Kirkland and J. C. Landenberger, Jr., Mining Engineers
Bruce Clemmer and Frank McQuiston, Metallurgists
Reno H. Sales—Summary.

Seven Field Trips

Geneva Works of the Columbia-Geneva Steel Div., U. S. Steel Corp. near Provo, about 35 miles south of Salt Lake City. A visit to largest integrated mill in West.

Bingham and Lark trip to view world's largest copper mines and the surface plant of one of the largest lead-zinc mines in the U. S.

Magna and Arthur Mills, a tour of the two 50,000-tpd concentrators of the Kennecott Copper Corp.

Garfield Smelter and Refinery trip includes American Smelting & Refining Co.'s copper smelter, world's largest, as well as the new Kennecott copper refinery.

Western Phosphates plant at Garfield is owned by AS&R, Kennecott, and Stauffer Chemical Corp. in partnership. Capacity is 90,000 tons of triple superphosphate per year.

Vitro Uranium mill located 10 miles south of Salt Lake City will be toured except for classified areas.

Kennecott Research and Engineering Center, a modern center equipped for pilot plant flotation studies, and pyro and hydrometallurgical testing.

Black Hills Regional Meeting Program Data

Calendar of Events

Saturday, October 1

Evening: Registration, Alex Johnson Hotel, Rapid City

Sunday, October 2

8:00 am to 4:00 pm: Registration, Mine Office, Yates Shaft, Homestake Mining Co., Lead. Registration Sunday evening, Alex Johnson Hotel, Rapid City. (Homestake trips, both mine and mill, will be formed continuously. Those taking the mine trip should bring old clothes and, if possible, hard hats.)

9:00 am to 1:30 pm: Bald Mountain mine and mill trips. The mine trip will require old clothes, hard hats, and flashlights.

Evening barbecue: Homestake Mining Co. is the host; followed by special presentation of the historic play, *The Trial of Jack McCall for the Murder of Wild Bill Hickok.*

Monday, October 3

8:00 am: Registration desk opens, Alex Johnson Hotel, Rapid City.

9:00 am to 12:00 m: Technical sessions, South Dakota School of Mines & Technology, Rapid City.

12:15 pm: Welcoming Luncheon, Ball Room, Alex Johnson Hotel.
Speakers: The Honorable Joe Foss, Governor of South Dakota; The Honorable Don L'Esperance, Mayor of Rapid City; F. L. Partlo, President, South Dakota School of Mines and Technology; and Renaldo D. Gallo, Chairman, Black Hills Section, AIME.

2:00 to 5:00 pm: Technical sessions, South Dakota School of Mines & Technology

Evening: Trips to points of technical interest in and near Rapid City.

Tuesday, October 4

8:00 am: Registration, Alex Johnson Hotel.

9:00 am to 12:00 m: Technical sessions, South Dakota School of Mines & Technology.

2:00 to 5:00 pm: Technical sessions, South Dakota School of Mines & Technology.

6:30 pm: Cocktail party, free to registrants, Bon-Air Restaurant, Rapid City.

7:30 pm: Banquet and dance, informal, Bon-Air Restaurant. **Banquet Speaker:** W. W. Mein, Jr., Vice President, AIME; **Toastmaster:** Nathaniel Herz.

Wednesday, October 5

8:00 am: Field trips, departing from Alex Johnson Hotel.

Technical Sessions

Monday am, October 3

General Geology of the Black Hills with Kodachrome Slides. By Edward L. Tullis, South Dakota School of Mines & Technology, Rapid City, S. D.

Commercial Flotation of Spodumene from Pegmatite of the Black Hills, South Dakota. By Gerald A. Munson and C. B. Harris, Lithium Corp. of America, Hill City, S. D.

Thick Seam Mining at Wyodak Coal Co. By Harold E. Ross, Wyodak Coal Co., Gillette, Wyo.

Geologic Environment and Distribution of Mineable Pegmatites in the Southern Black Hills, South Dakota. By J. S. Redden, USGS, Denver.

Geophysical-Geochemical Prospecting for Uranium. By M. E. Denson, USGS, Denver.

Monday pm, October 3

Minerals in River Basin Development. By John H. East, Jr., USBM, Denver.

Geology of the Homestake Mine. By A. L. Slaughter, Homestake Mining Co., Lead, S. D.

Mining Methods at Homestake. By William C. Campbell, Homestake Mining Co., Lead, S. D.

Early Black Hills Metallurgical History. By J. V. N. Dorr, Dorr-Oliver Inc., Stamford, Conn.

Tuesday am, October 4

Outlook for Gold and Gold Mining. By Guy N. Bjorge, Homestake Mining Co., San Francisco.

Current Milling Practice at Homestake. By Frank Howell, Jr., Homestake Mining Co., Lead, S. D.

Mining and Milling at the Bald Mountain Mining Co. By Paul Miller, Bald Mountain Mining Co., Lead, S. D.

Exploration for Concealed Deposits in the Monte Carlo, Ferguson and Beecher No. 3 Pegmatites, Black Hills, South Dakota. By J. J. Norton and D. M. Sheridan, USGS, Denver.

Tuesday pm, October 4

Production of Ammonia Synthesis Gas from Lignite in an Annular Retort Gasifier. By Walter P. Oppelt, USBM, Grand Forks, N. D.

Airborne Geophysics in the Search for Uranium Deposits, Black Hills, South Dakota. By T. M. Rizzi, Homestake Mining Co., Lead, S. D.

Geology of Northern Black Hills Bentonite District. By S. H. Patterson, USGS, Denver.

Panel Discussion: "What Should be the Future Objectives of Mineral Industry Education?"
A young engineer: (to be chosen)
An industrial administrator: A. H. Shoemaker, Homestake Mining Co., Lead, S. D.
An educator: F. L. Partlo, South Dakota School of Mines & Technology, Rapid City, S. D.

Special Entertainment for Ladies

Sunday, Oct. 2, 1:00 pm: Luncheon in northern Black Hills followed by social afternoon. Arranged by Northern Black Hills Section, Mrs. R. H. Richards, Chairman.

Monday, Oct. 3, 2:00 pm: Buses leave Alex Johnson Hotel, Rapid City, for tour of Ellsworth Air Force Base (B-36) with tea at the Officers' Club. Arranged by Rapid City Section, Mrs. Edward L. Tullis, Chairman.

Tuesday, Oct. 4, 12:30 pm: Buses leave Alex Johnson Hotel for luncheon to be served at Powder House Lodge at 1:00 pm, followed by trip to Mt. Rushmore Shrine of Democracy. Arranged by Rapid City Section.

Study Proposed for Headquarters Location

AIME and the nation's other top engineering societies were offered another approach recently to the housing problem presented by their outgrown, 50-year old building.

The new proposal was embodied in a letter from a newly formed national group of 21 of the country's engineering educators and industrial leaders to United Engineering Trustees Inc. and the five major professional engineering societies. The proposal, referred to as the Kelly letter, which was read at the June 15th Board meeting follows:

To: United Engineering Trustees Inc.,
ASCE, AIME, ASME, AIEE, and AIChE:

We, the undersigned, as members of academic and industrial organizations that are concerned with the welfare of your Societies, are addressing you collectively concerning the choice of a new headquarters for your organizations. While some of us already have indicated a preference for one city and others of us for another, we are agreed that the fundamental desirability of approaching this matter on a national rather than a local basis transcends our personal preferences.

The progress of our highly industrialized society is dependent on its scientific and technologic strength. A major portion of the technology upon which our industries depend is encompassed within the combined scope of your Societies, and a large portion of the professional men contributing to the technology and its practice are members of one or more of your organizations. It is because of the important place in our society that you occupy that we are concerning ourselves with the choice of a location for your new headquarters.

We understand that your present building at 33 W. 39th St., New York City, which is now some 50 years old, has become grossly inadequate for your operations and that you have been planning for some time a new headquarters building adequate for present and future needs. With the use of the funds of your depreciation reserve and the funds to be realized from the sale of the present property, you will require about $2.5 million of new funds. As an inducement to locate the headquarters in their cities, at least three have indicated that local organizations will contribute generously to your building fund. The suggested contributions, we understand, have ranged from approximately $500,000 to $1.5 million.

While this evidence of civic pride is praiseworthy, we believe the matter of local contributions is of secondary importance in your choice of location. We suggest rather that the long-range interests of the Societies in serving their professions and the nation are paramount, and that maximum effectiveness of your operations is of controlling importance.

Most industries of the country benefit directly from the technologies included in your organizations. We are sure they will contribute generously to your building funds if your location is chosen on the broad-gaged basis suggested. If such a choice is made, a group of the undersigned will organize a large national committee, representing all sections, all technologies in your Societies, and a variety of industries, to conduct a nationwide drive for funds.

We understand that several studies of location have been made. Perhaps they have not been sufficiently coordinated and integrated. We respectfully suggest that a competent and independent management or engineering firm be employed to coordinate and evaluate these studies and to make additional examinations as required, and when the integrated studies are available, that you make your selection on the basis we have suggested.

As you no doubt realize, many large industries employ outside counsel for studies to determine the best location for new units of their business. There are several organizations that are competent to make such studies. We suggest that you select from among them one for the task. Some of us who are signing this letter will provide the funds to cover its cost.

While we are not now in a position to guarantee the amount of the subscriptions for your building fund, we are confident that the amount required beyond your resources can be raised through a campaign of the scope we have indicated. We assure you that a well organized, diligent and competent effort will be made and continued until the required sum is available, which we understand is approximately $2.5 million.

Respectfully submitted,

SIGNATORIES: James F. Bell, Chairman, Committee on Finance and Technological Progress, General Mills Inc., Minneapolis. Detlev W. Bronk, President, National Academy of Sciences, Washington, D. C. Ralph J. Cordiner, President, General Electric Co., New York. James Creese, President, Drexel Institute of Technology, Philadelphia. Jess H. Davis, President, Stevens Institute of Technology, Hoboken, N. J. Lee A. DuBridge, President, California Institute of Technology, Pasadena, Calif. T. Keith Glennan, President, Case Institute of Technology, Cleveland. Eugene G. Grace, Chairman of the Board, Bethlehem Steel Corp., New York. Crawford H. Greenewalt, President, E. I. du Pont de Nemours & Co., Wilmington, Del. William H. Harrison, President, International Telephone & Telegraph Corp., New York. Livingston W. Houston, President, Rensselaer Polytechnic Institute, Troy, N. Y. Frederick L. Hovde, President, Purdue University, Lafayette, Ind. Kaufman T. Keller, Chairman of the Board, Chrysler Corp., Detroit. Mervin J. Kelly, President, Bell Telephone Laboratories Inc., New York. Horace P. Liversidge, Chairman of the Board, Philadelphia Electric Co., Philadelphia. John L. McCaffrey, President, International Harvester Co., Chicago. Alfred P. Sloan, Jr., Chairman of the Board of Directors, General Motors Corp., New York. Charles A. Thomas, President, Monsanto Chemical Co., St. Louis. Martin D. Whitaker, President, Lehigh University, Bethlehem, Pa. Robert E. Wilson, Chairman of the Board, Standard Oil Co. of Indiana, Chicago. John D. Wright, President, Thompson Products Inc., Cleveland.

Following exhaustive discussion of the whole problem of the location for the engineering societies headquarters building the AIME Board moved

That our Board expresses appreciation to Dr. Kelly and will take advantage of the offer as indicated in his letter of June 8; and this body holds in abeyance any action on the Pittsburgh offer.

Further action on this proposal and on the whole new building problem now depends on agreement by the societies concerned.

AIME Board Names Two New Honorary Members

At the June meeting of the board of directors AIME elected two of the most distinguished men in the mining industry to Honorary Membership: Louis S. Cates and George M. Humphrey. The number of living Honorary Members is limited to twenty, and these elections bring the roster up to eighteen.

Louis Shattuck Cates, chairman of the board of the Phelps Dodge Corp., was President of the AIME in 1946, and has been a member since 1904. He was awarded the Institute's William Lawrence Saunders Medal in 1939 "for signal accomplishment in the conception and application of superior mining technique and in the organization and administration of major mining and metallurgical enterprises."

George Magoffin Humphrey, Secretary of the Treasury, became a member of the AIME in 1922 and received its Charles F. Rand Medal in 1947 "for constructive leadership in establishing great enterprises for the production of iron ore, of steel, and of coal; for signal success in the administration of large organizations engaged in these industries so vital to the economy of our country."

Lima Peru Section Holds Annual Meeting

The annual meeting, held Saturday June 18, marked another milestone in the history of the Lima, Peru, Section. It was the third anniversary of the section, founded June 1952.

The occasion was marked with a formal cocktail party-dinner dance at the Lima Country Club attended by about 250 members and guests. Guest of honor was Michael L. Haider, AIME President 1952 to 1953. Carl W. Westphal, Section Chairman for three terms, passed the gavel to incoming Chairman Ernesto A. Baertl.

Also participating in the meeting was the Lima Woman's Auxiliary under the chairmanship of Mrs. T. A. Jackson. The ladies presented retiring Section Chairman Westphal with an appropriately engraved silver cigarette box in the name of the AIME Woman's Auxiliary group.

Entertainment capped the evening events. Several acts were presented, all talent originating within the membership. The balance of the affair was turned over to the dance which lasted until 3:30 am.

Program for the AIME-ASME Joint Solid Fuels Conference, October 19 to 21, Columbus, will appear in the September issue.

Fourth Annual Drilling Symposium Scheduled

The University of Minnesota will present its fourth annual Drilling Symposium October 13, 14, and 15 at the Center for Continuation Study on the Minneapolis campus of the University of Minnesota. The subject this year is the use of tungsten carbide in rotary exploration drilling. The program is not yet definite in all details, but the general schedule will cover the metallurgy of tungsten carbide and the mounting or arrangement of tungsten carbide in bits on Thursday.

Friday the sessions will go into the experience of rotary drillers with tungsten carbide in bits used in the U. S. and elsewhere. Combined use of rotary and percussion methods with tungsten carbide bits will also be a topic. Saturday's session will be devoted to general discussion.

A feature of part of the discussion will be reports from continental European experts. The symposium will then consider the use of combined rotary and percussion methods.

Inquiries and application for registration should be sent to the Director, Center for Continuation Study, University of Minnesota, Minneapolis 14, Minn.

PERSONALS

P. K. STRONG

P. K. Strong is tunnel superintendent, Instituto Costarricense de Electricidad, a Costa Rican Government company on the order of TVA. Mr. Strong is working on the La Garita hydroelectric project. Before accepting this position, Mr. Strong had been Central American manager, Ingersoll-Rand Co., for nine years. He is still available for engagements on a consulting basis in mining. Mr. Strong's address is: Apartado 3423, San José, Costa Rica.

Nelson Severinghaus, Jr., mining engineer, Tennessee Copper Co., Copperhill, Tenn., is assistant production manager, Calcium Products Div., Georgia Marble Co., Tate, Ga.

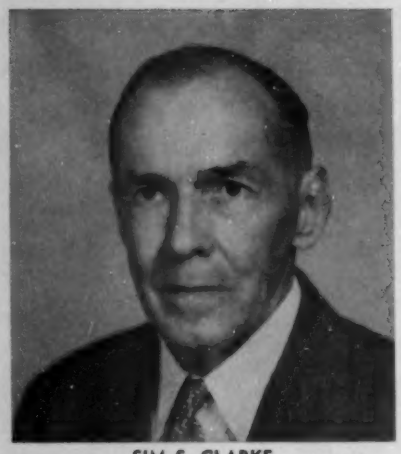
Herbert D. Fine, manager, Bald Mountain Mining Co., Trojan, S. D., has resigned to become assistant mine superintendent, Fresnillo Co., Fresnillo, Zacatécas, Mexico.

S. K. de Kok is reduction officer, Hartebeestfontein Gold Mining Co. Ltd., Stilfontein, Transvaal, South Africa.

Ian H. Carne, U. S. representative, Broken Hill Proprietary Co. Ltd., has returned to the company's head office in Melbourne, Australia. Mr. Carne has been the company's U. S. representative for four years.

John H. Fair, formerly with the U. S. Smelting Refining & Mining Co., Lark, Utah, is now employed by Minerals Engineering Co., Glen, Mont.

Vernon L. Mattson, director of the Research Institute, Colorado School of Mines, Golden, has been appointed to the newly created position of manager, mining and ore processing, Kerr-McGee Oil Industries Inc., according to **Dean A. McGee,** president. Mr. Mattson formerly acted as consultant to Kerr-McGee on matters pertaining to activities in metallurgical research, uranium mining and milling, and the mining and processing of potash.



SIM S. CLARKE

Sim S. Clarke has entered private consulting practice on mine mechanization at 429 Cherokee Avenue, Baxter Springs, Kan. Mr. Clarke has held many positions in the mining field, including that of mining engineer and later division superintendent, St. Joseph Lead Co.; mining engineer and mine superintendent, Eagle-Picher Co.; superintendent of mines, Commerce Mining & Royalty Co., Miami, Okla. In 1940 he returned to Eagle-Picher as superintendent of mines and in 1948 was promoted to general superintendent of mines, Tri-State Mines Div., Cardin, Okla. Mr. Clarke was awarded the AIME William Lawrence Saunders Gold Medal in 1954.

John W. Donahey is director of public relations and advertising, Foote Mineral Co., Philadelphia. Mr. Donahey was formerly head of the Ceramic Div. of Foote's Research & Development Laboratories and transferred to the Sales Div. in 1953.

R. B. Fulton is manager of the Cincinnati district, Allis-Chalmers Mfg. Co., General Machinery Div. Mr. Fulton succeeds **W. F. Daly,** who has retired after more than 30 years of service with Allis-Chalmers.

Henry S. Wingate, president, International Nickel Co. of Canada Ltd., is a director of the Bank of Montreal. Mr. Wingate joined International Nickel 20 years ago and became president of the company and of its U. S. subsidiary in 1954.

P. T. Bloomer, operating superintendent, Sullivan mine, Consolidated Mining & Smelting Co. of Canada Ltd., has been appointed general superintendent, outside mines. Mr. Bloomer has been with Cominco since 1920. His paper "Pillar Extraction at the Sullivan Mine," won the Leonard Medal of the Engineering Institute of Canada in 1948.

Alexander Brown, chairman of the board, Cleveland-Cliffs Iron Co., Cleveland, has been elected a director and chairman of the committee on iron ore, American Iron and Steel Institute, New York.

Spencer S. Shannon is director of the newly created office of Minerals Mobilization in the Interior Dept., U. S. Bureau of Mines.

A. G. Gilbert, formerly manager, standard product sales, Heyl & Patterson Inc., Pittsburgh, has been appointed general sales manager, Wilmot Engineering Co., Hazleton, Pa. Mr. Gilbert will be in charge of sales for all the company's divisions. His headquarters will be at Wilmot's White Haven, Pa., plant. **Harold R. Middleton,** formerly sales manager, will direct advertising and sales promotion.

Phillip L. Merritt, senior geologist, E. J. Longyear & Co., Minneapolis, has been elected director of Sodak Uranium & Mining Co. Inc., Edgemont, S. D. Before joining E. J. Longyear & Co., Mr. Merritt was assistant director, exploration, AEC Div. of Raw Materials. During World War II he was chief, Raw Materials, Manhattan Project, U. S. Corps of Engineers. Prior to that he was with American Cyanamid Co. and the Dept. of Mines in Colombia.

Jack O. Jones, president, Monogram Uranium & Oil Co., and **W. E. Haldane,** vice president, Sodak Uranium & Mining Co. Inc., have been elected directors of the Uranium Ore Producers Assn., Grand Junction, Colo.

Emo D. Porro is engineering assistant to the director, Stanford Research Institute, Stanford, Calif. Mr. Porro is a graduate of the University of California at Berkeley. In 1942 he became assistant to the vice president, Henry J. Kaiser Co., Washington, D. C. Mr. Porro joined the staff of Stanford Research Institute in 1948 and has held several positions including that of manager, chemical and metallurgical engineering section.

H. W. Millett, mill operator, Geita Gold Mining Co. Ltd., Tanganyika, East Africa, has returned to England. He will be living in Hove, Sussex.

Thomas F. Reed is assistant director, Applied Research Lab., U. S. Steel Corp., Monroeville, Pa.

A. J. Martin, U. S. Bureau of Mines, Denver, has been transferred to Washington, D. C. Mr. Martin is living in Arlington, Va.

Merle H. Guise has completed a visit to Australia and has gone to Indonesia and Malaya where he expects to revisit some of the mining areas he covered after World War I. Mr. Guise can be reached through the American Express Co., Singapore, while in the Malaya area.

Edward Matsen, general mine foreman, Climax Molybdenum Co., Climax, Colo., is now acting mine superintendent, San Mauricio Mining Co., José Panganiban, Camarines Norte, P. I.

J. ROSENBLATT

Joseph Rosenblatt, president, Eimco Corp., Salt Lake City, has been named a Knight of the French Legion of Honor. This award was given to Mr. Rosenblatt for meritorious service to the mining industry and was made in absentia at the International Mining Congress in Paris. Mr. Rosenblatt is president of Société Française Eimco. He is also a director of Howe Sound Mining Co.

Fred J. Kirkman is executive vice president, Burgess Battery Co., Freeport, Ill. Mr. Kirkman was general manager, Canadian Div. at Niagara Falls, Ont., and has been with the company since 1934.

Wessel J. C. Venter, 1955 graduate of the University of Arizona, Tucson, is with the Tsumeb Corp. Ltd., Tsumeb, South West Africa.

C. G. Rice, vice president and general manager, oil operations, U. S. Smelting Refining & Mining Co., Boston, has been elected executive vice president and a member of the executive committee. **J. V. Neuman, Jr.,** manager, Southern Div., Oil Dept., is a vice president. **H. G. Peacock,** assistant to the president, has been appointed assistant to the executive vice president.

Leslie S. Voltz, general superintendent, Franklin County Coal Corp., Royalton, Ill., is now in the engineering dept., Consumers Co., a division of Union Chemical & Materials Corp., Chicago.

J. R. Thoenen, U. S. Bureau of Mines, Knoxville, Tenn., was awarded an honorary Master of Engineering degree from Michigan College of Mining & Technology, Houghton. Mr. Thoenen has had many years' experience in the mining profession, and has been consulting engineer for mining companies in Canada and Greece, as well as in the U. S.

B. A. Daley, chief metallurgist, Servel Inc., Evansville, Ind., has been promoted to chief engineer of the Defense Div. Mr. Daley joined Servel in 1936 as a metallurgist.

P. J. Cutting is manager, Minerales y Metales Industriales S. A. de C. V., San Luis Potosí, S. L. P., Mexico. Mr. Cutting was with Elizalde & Co. Inc., Manila, P. I.

Oscar A. Glaeser, U. S. Smelting & Mining Co., Salt Lake City, is president of the Utah Coal Operators Assn.

Thomas B. Rees is sales representative, Charleston, W. Va., district, Allis-Chalmers Mfg. Co. Mr. Rees was formerly with Goodman Mfg. Co., Chicago.

Morton E. Pratt, Jr., mine superintendent, Trench Unit, American Smelting & Refining Co., Patagonia, Ariz., is now at the Keystone Unit, Crested Butte, Colo.

C. S. Beech, who was with Stearns-Roger Mfg. Co., Tucson, Ariz., is sales engineer for the company at Denver.

Edward S. Smith is assistant melting superintendent, electric furnace dept., Universal-Cyclops Steel Corp., Bridgeville, Pa.

George H. K. Schenck is project engineer with the U. S. Atomic Energy Commission, Grand Junction Operations Office, Colo. Prior to joining the AEC he was a lieutenant in the U. S. Army.

David Kerr-Cross has returned to England from Southern Rhodesia. His address is: Low Farm, Swilland, Ipswich, Suffolk.

PAUL W. ALLEN

Paul W. Allen, who was plant manager, National Lead Co.'s MacIntyre Development, Tahawus, N. Y., has joined the Cyprus Mining Co. and will be located in Los Angeles.

Thomas D. Henderson, mill superintendent, Copper Cities Mining Co., Miami, Ariz., was awarded the professional degree of Metallurgical Engineer at the University of Arizona, Tucson. Mr. Henderson received a B.S. degree from the university in 1932.

William C. Denison has been elected to the board of directors, American Brake Shoe Co., New York. Mr. Denison is president, Denison Engineering Co., which was recently acquired by American Brake Shoe Co.

Gordon M. Miner is superintendent of mining, Foley Bros. Inc., Pleasantville, N. Y. He was with U. S. Smelting Refining & Mining Co., Bayard, N. M.

O. Herneryd, Boliden Mining Co., Skelleftehamn, Sweden, is now sales manager of Bolidens Gruvaktiebolag in Stockholm.

Donald W. McGlashan, research professor and head, mineral dressing dept., Montana School of Mines, Butte, has been awarded the professional degree of Metallurgical Engineer by the University of Idaho, Moscow.

B. A. Gruber, The Ethyl Corp., Baton Rouge, La., is now with Monsanto Chemical Co., Research & Engineering Div., Dayton.

Edward P. Larsen, Hewitt-Robins Inc., Chicago, is with Hewitt-Robins (Holland) N.V., Amsterdam, Holland.

Avery A. Drake, Jr., U. S. Geological Survey, Mineral Deposit Branch, Denver, has been transferred to Washington, D. C.

L. G. Felderman, manager, sales engineering, Joy Mfg. Co., Franklin, Pa., has been appointed sales manager, rock mechanization, with headquarters at Franklin. Mr. Felderman has been with Joy since 1930. He was graduated from Tri-State College, Angola, Ind.

James C. Dudley, mining geologist, is with Cyrus J. Lawrence & Sons, New York.

J. G. Campbell, formerly with Aluminium Ltd., Montreal, is managing director, Demerara Bauxite Co. Ltd., Georgetown, British Guiana.

Richard Hamburger, mining engineer, Inspiration Copper Co., Inspiration, Ariz., has joined the Denver Exploration Branch of the AEC as geologist.

W. B. Dancy has been appointed assistant development and control superintendent, Potash Div, International Minerals & Chemical Corp., Carlsbad, N. M. Mr. Dancy will assist **H. P. Clark** in the administration and operation of the department. **Robert H. Lane** has been promoted to mine engineer and will be responsible for all mine engineering problems. He succeeds **M. I. Signer** who is now exploration superintendent in charge of exploration and preliminary development of International's potash lands in Canada. **Adolph V. Mitterer** succeeds Mr. Lane as geologist. Mr. Mitterer joined the company in 1954, having previously worked for the Colorado School of Mines.

Joseph G. Wargo, instructor in geology, Miami University, Oxford, Ohio, is now geologist with the Bear Creek Mining Co., Eureka, Utah.

A. J. McDONELL

Edwin R. Shorey, chairman, mining and metallurgy dept., University of Wisconsin, Madison, is retiring. Mr. Shorey has been with the university for 36 years. He is succeeded by **Philip C. Rosenthal** of the same department.

Didier Journeaux, patent attorney-in-charge, general machinery section, Allis-Chalmers Mfg. Co., Milwaukee, has retired after nearly 30 years with the firm.

G. Allen Lovell has been elected a vice president of U. S. Rubber Co., New York, and appointed general manager of the Mechanical Goods Div. Mr. Lovell joined the company in 1918 as an apprentice in the Williamsport, Pa., plant.

George F. Dixon, Jr., has been elected president, Dart Truck Co., Kansas City. For the past year and a half, Mr. Dixon has served as vice president, Carlisle Corp, Carlisle, Pa., of which Dart is a subsidiary. **Furber Marshall,** former president, Dart Truck Co., is now chairman of the board of directors. Mr. Marshall is president of the Carlisle Corp.

H. C. Milton has been appointed manager, manufacturers chemicals dept., Industrial Chemicals Div., American Cyanamid Co., New York. **R. L. Lambert** is assistant manager, and **J. F. Allen** is Eastern regional sales manager for the department. These appointments were announced by **R. E. Sumner,** manager of the division.

B. R. Sharan is with the Bald Mountain Mining Co., Trojan, S. D. Mr. Sharan is a recent graduate of South Dakota School of Mines and Technology, Rapid City.

C. E. Bowker is mine manager, Mogul Mining Corp. Ltd., West Broughton, Que. Mr. Bowker was with the Jonsmith Mines, Capreol, Ont.

Joe Webb Peoples, chairman, geology dept., is on two years' leave of absence from Wesleyan University, Middletown, Conn. He will be in the Philippine Islands with the U. S. Geological Survey.

John G. Hall, assistant plant manager, National Lead Co.'s MacIntyre Development, Tahawus, N. Y., is now plant manager. **Archie McDonell,** chief engineer, and **Charles Begor, Jr.,** general superintendent, have been appointed assistant plant managers.

JOHN G. HALL

Paul Fenwick has been appointed Northeastern sales manager, Marion Power Shovel Co., Marion, Ohio. Mr. Fenwick will continue to make his headquarters in New York. **Walter Pierson** is Southeastern sales manager, with headquarters in Atlanta.

Robert Campello has been appointed sales manager, Marion Power Shovel Co., Marion, Ohio.

C. BEGOR, JR.

A. L. Stewart is central region representative, Allis-Chalmers Mfg. Co., with headquarters in the Cleveland district office. Mr. Stewart joined Allis-Chalmers in 1942 after graduating from the Missouri School of Mines & Metallurgy.

C. Roger Sutton, senior metallurgist, Argonne National Laboratory, AEC, for the past five years, has joined the Development & Research Div., International Nickel Co. Inc., stainless steel and heat resistant alloys section.

Carl I. Aslakson, geodesist, has joined the staff of Aero Service Corp., Philadelphia. Mr. Aslakson was formerly with the U. S. Coast & Geodetic Survey.

Thomas K. Voyer, personnel and safety director, International Smelting & Refining Co., Tooele, Utah, has been elected president, Utah State Fair Board.

E. F. Goodner, president, American Gilsonite Co., Salt Lake City, and **Miles P. Romney**, manager, Utah Mining Assn., Salt Lake City, are members of a 44-man school study panel appointed by Gov. J. Bracken Lee.

Joseph R. Vogan, buyer, purchasing dept., American Brake Shoe Co., New York, has been appointed purchasing agent for steel products. Mr. Vogan will continue to be located in New York.

Thomas Hart has joined White Pine Copper Co., White Pine, Mich., as junior engineer. Mr. Hart was graduated in June from South Dakota School of Mines & Technology, Rapid City.

Arthur E. Granger has been named chief, Geologic Branch, AEC, Grand Junction, Colo. Mr. Granger is a graduate of the University of Utah, Salt Lake City, and the University of Washington, Seattle. He was with the U. S. Geological Survey for 15 years and before joining the AEC at Grand Junction in 1954, was employed by U. S. Steel Corp., San Francisco. Mr. Granger succeeds **Robert J. Wright** who resigned recently to enter private business.

R. A. QUADT

Raymond A. Quadt, director of research and development, Hunter Douglas Corp., Riverside, Calif., has been promoted to assistant vice president. Mr. Quadt will continue his duties as director of research and development and be responsible for the company's commodity sales. Prior to joining Hunter Douglas Corp. in 1950, Mr. Quadt was director, aluminum development, Federated Metals Div., American Smelting & Refining Co., Barber, N. J.

Amorn Methikul and **Damner Sithiprasasna**, geologists with the Royal Dept. of Mines in Bangkok, Thailand, and **Ignacio Antonio**, geologist with the Philippines Bureau of Mines in Manila, recently attended a course of instruction in the manufacture and use of diamond core drilling equipment conducted by the E. J. Longyear Co., Minneapolis. Earlier this year they attended classes at various U. S. universities. These three visiting geologists are here as part of the Government's program to provide people of other nations with training and experience that will benefit their countries.

Thor Gjelsteen is geologist, Uranium Div., The Superior Oil Co., Grand Junction, Colo.

John G. Barry, consulting mining engineer, Mexico, D.F., is now staff engineer, AEC, in the office of **E. R. Gordon**, division director, Grand Junction, Colo. Mr. Barry will act in an advisory capacity to the director of the Exploration Div. and provide liaison with the Mining & Processing Divisions. Mr. Barry, a graduate of Massachusetts Institute of Technology, was an instructor in geology at the University of North Dakota and at MIT, and president of Texas College of Mines. He was chief mining geologist for the American Smelting & Refining Co., El Paso, Texas, and has done private consulting work in Mexico and the southwestern U. S. During World War I Mr. Barry was a lieutenant colonel in the Chemical Warfare service in France. Mr. Barry succeeds **David D. Baker**, now deputy director of the Mining Div.

C. McFARLIN, SR.

Carl McFarlin, Sr., has been elected an executive vice president of Merritt-Chapman & Scott Corp., in charge of the Chemical Paint & Metallurgical Div. Mr. McFarlin is president and a director of Tennessee Products & Chemical Corp., Nashville, Tenn., which was recently acquired by Merritt-Chapman & Scott Corp. He will remain at the Nashville offices of Tennessee Products & Chemical Corp. Mr. McFarlin joined the Tennessee company in 1938 as vice president and general manager, and has been president for the past 16 years. During World War I he served overseas with the U. S. Army Corps of Engineers, and was a member of the advisory committee on manganese ore and ferromanganese of the War Production Board during World War II.

Royal S. Foote has resigned as head of the Geophysical Exploration Branch, Raw Materials Div., AEC, to form Resources Development Corp., a new company with offices in New York and Denver.

Claude B. Kershner, Phoenixville, Pa., is director of purchases, Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.

Robert M. Johnson has been appointed district sales representative, Leschen Wire Rope Div., H. K. Porter Co. Inc. His territory includes New England and eastern New York State.

Leo H. Glanville, Climax Molybdenum Co., Climax, Colo., has retired because of ill health. Mr. Glanville was safety engineer for Climax for two and a half years and ventilation engineer for more than 15 years. He is internationally known for mine ventilation work and layout of mine ventilation systems. Mr. Glanville is now living in Camarillo, Calif.

Ralph Meyertons, planning engineer, Warren Foundry & Pipe Corp., Mt. Hope, N. J., and **John Englund** of Hibbing, Minn., have recently joined Climax Molybdenum Co., Climax, Colo. They will be working under **Fred Hoff** in the metallurgical research dept.

William L. Kleitz, president and director, Guaranty Trust Co., New York, has been elected a director of American Smelting & Refining Co., New York. Mr. Kleitz was graduated from Cornell University in 1915. He joined the Guaranty Trust Co. in 1919 and was elected president in 1947.

Charles H. Kline, manager, Chemical Development Div., Climax Molybdenum Co., New York, has announced the appointment of the following four managers: **Elwin E. Smith,** lubricant development; **George S. Cripps,** agricultural development; **Herbert Kay,** new chemical development; and **Benjamin Danziger,** catalyst and pigment development.

William D. Stone, superintendent, perlite plants, Great Lakes Carbon Corp. of Florence, Colo., and Socorro, N. M., since 1950, has been promoted to assistant manager, geology & quarry operations dept., Perlite & Dicalite Divisions.

Richard Bullock, mining engineer, Empire Zinc Div., New Jersey Zinc Co., Gilman, Colo., is now with the research dept., St. Joseph Lead Co., Bonne Terre, Mo.

Rolph A. Person, chemical engineer, Research Div., Allis-Chalmers Mfg. Co., West Allis, Wis., has joined Union Carbide & Carbon Co., Niagara Falls, N. Y., as chemical and development engineer.

OBITUARIES

Barclay G. Anderson

An Appreciation by

E. D. Gardner

Barclay G. Anderson of Berryville, Va., died suddenly on Monday, May 16, while at work. Mr. Anderson was born at White Sulphur Springs, Mont., on Aug. 6, 1891. He attended the University of California, and received his E.M. Degree from Columbia University in 1916. He served in World War I in Company B, 318th Engineers, and saw service in France. After return from the Service, he worked as a mining engineer in the States (California and New Mexico) and in Mexico and Canada. He joined the U. S. Bureau of Mines in 1950, working at Mount Weather and in Cuba.

In 1952 Mr. Anderson was on loan to the United Nations as an expert on mining methods and was sent to Yugoslavia.

Mr. Anderson was a member of the American Legion, the Masonic Order, the Canadian Institute of Mining and Metallurgy, the AIME (1916), and was a lifelong member of the All Souls Episcopal Church of Berkeley, Calif.

Mr. Anderson is survived by his wife, Frances Harsh Anderson, Berryville, Va., and a son, Barclay H. Anderson, of Toronto. Burial was in Arlington National Cemetery Friday, May 20.

Dudley Denison Homer (Member 1920) of Essex, Conn., died May 16, 1955. Mr. Homer is credited with many original contributions and improvements of mining processes. He was managing director, South American Metal Co., Santiago, Chile, and for 22 years, director and treasurer of Minas de Matahambre, Pinar del Rio, Cuba. Mr. Homer was born in Mystic, Conn., in 1886. He attended South Dakota School of Mines and graduated in 1910 from Mackay School of Mines, University of Nebraska. From 1910 to 1914 his practical experience was gained as engineer, miner, and foreman in various mines, including Homestake mine, Lead, S. D., Speculator mine, Butte, Mont., and Mary McKinney mine, Cripple Creek, Colo. He was a field engineer with Seeley W. Mudd in Los Angeles from 1914 to 1915. Mr. Homer was later general superintendent, Butters Divisadero Co., El Salvador, and Jerome del Monte Copper Co., Arizona, and general manager, Chontales Mines Co., Nicaragua. He joined Minas de Matahambre as general manager in 1922. Mr. Homer returned to New York with American Metal Co. in 1944 and two years later was named managing director of South American Metal Co., Santiago, Chile. He retired in 1952.

Karl L. Landgrebe (Member 1912) of Birmingham died May 13, 1955. He was formerly vice president in charge of administration for U. S. Steel's Tennessee Coal & Iron Div., Birmingham. Mr. Landgrebe was born in Cleveland in 1876 and was graduated in 1898 with a B.S. from Case School of Applied Science, Cleveland. He first worked for Illinois Steel Co., South Chicago, Ill., as furnace practice blower, general blower, and assistant superintendent of blast furnaces. Mr. Landgrebe was later general superintendent, Toledo Furnace Co., Toledo, and superintendent, blast furnaces, Bethlehem Chemical Steel Co., South Bethlehem, Pa. He joined the Tennessee Div. in 1910. During World War II Mr. Landgrebe resigned to serve as vice president of a company manufacturing gun shells.

John H. Lidgerwood (Legion of Honor Member 1902) died Mar. 9, 1955 at the New York Yacht Club. He was a former president of the Lidgerwood Mfg. Co., a manufacturer of heavy machinery and hoists. Mr. Lidgerwood, who was born in Morristown, N. J., in 1875, was a descendant of Judge Stephen Vail, owner of the old Iron Works at Morristown which dated back to the Revolutionary War period. Mr. Lidgerwood was graduated from Stephens Institute of Technology, Hoboken, N. J., in 1899 and from Columbia University School of Mines in 1901. He sold Lidgerwood Co. after World War II and made his home at the New York Yacht Club.

Necrology

Date of Election	Name	Date of Death
1903	A. O. Cautley	May 22, 1955
1936	A. A. DeMelik	June 16, 1955
1933	J. M. Forbes	June 6, 1955
1944	G. A. Lillieqvist	May 31, 1955
1953	D. A. McKinley	May 27, 1955
1928	R. H. Parsons	June 9, 1955
1952	Ronald Rosenkranz	June 13, 1955
1929	W. G. Saville	February 1954
1949	David B. Scott	June 20, 1955
1902	Howard D. Smith	Apr. 6, 1955
1919	Silas C. Stathers	Apr. 29, 1955
1944	Stephen M. Swain	June 21, 1955
1920	Rufus E. Zimmerman	May 22, 1955

The company is now located in Superior, Wis.

James Farley McClelland (Legion of Honor Member 1903) died May 6, 1955 in Greenwich, Conn. He was a retired vice president and director of Phelps Dodge Corp., New York. Mr. McClelland was born in Poughkeepsie, N. Y., in 1878 and was graduated with an E.M. from Columbia University in 1900. He then taught geology and mining, first at the University of Wyoming, and later at Columbia, Leland Stanford, and Yale. From 1902 to 1905 Mr. McClelland was in general mining practice in Tonapah, Nev. In 1917 he served with the Signal Corps and the Bureau of Aircraft Production in Washington, D. C. Following World War I Mr. McClelland became a consulting engineer with Liberty National Bank, New York, and from 1922 to 1929 he was with the New York Trust Co. In 1929 Mr. McClelland was vice president, Chemical Bank & Trust Co., New York, resigning this position in 1931 to become vice president and director, Phelps Dodge Co. He resigned as vice president in 1947, but continued as director until 1952. Mr. McClelland was the author of the section "Exploitation of Mineral Deposits" in Peele's handbook.

Jean Model (Member 1949) died May 29, 1955 in New York of bulbar poliomyelitis. Mr. Model, president of Colombian Mining & Smelting Co., Bogotá, was stricken in Colombia and was flown to New York in an iron lung on a Military Air Transport Service plane May 4. He was born in Belgium in 1915 and studied at the Universities of Brussels and Zurich. From 1936 to 1941 Mr. Model was with the Ste Financière de Transports et d'Entreprises Industriels S.A. (SOFINA). In the early part of World War II he served in the Belgian Army and came to this country in 1940 where he served as a pilot in the Army Transport Command. Mr. Model was president and owner of Sonrisa Mining Co. of Colombia and New York, a director of Western Credit Corp., and also connected with Export International Corp. and Popular Custodian Corp. Naturalized in 1943, Mr. Model was a Presidential elector of Connecticut in 1952 and served on the Presidential Assay Commission that year.

Eugene G. Snedaker (Member 1948) died Apr. 7, 1955. Mr. Snedaker was for many years general superintendent, secretary-treasurer, Ohio Copper Co. of Utah, Lark, Utah. He was born in Colorado in 1890 and received his E.M. from Colorado School of Mines in 1914. In 1915 Mr. Snedaker was employed by Goldfield Consolidated Mines, Goldfield, Nev., and became field engineer, Goldfield Consolidated Exploration Co., in 1916. During World War I he served as first lieutenant, 4th U. S. Engineers, and spent nine months in the Army of Occupation in Coblenz, Germany, as captain and adjutant to the Military Commander. From 1920 to 1927 Mr. Snedaker was associated with Bagdad Copper Co., New York, and from 1928 to 1933 he was manager, Electrical Products Corp., in Denver and Salt Lake City. In 1934 Mr. Snedaker rejoined Goldfield Consolidated Exploration Dept. as field engineer and remained until 1937, when he joined Ohio Copper.

Cleve A. Stover (Member 1939) died Dec. 18, 1954. A mining engineer with many years of experience in Mexico, Mr. Stover recently had been living in San Antonio, Texas. He was born in Texas in 1903 and following graduation from Texas College of Mines in 1927 worked with the Service Div., Copper Queen Branch, Phelps Dodge Corp., Bisbee, Ariz. For the next three years Mr. Stover was employed by Moctezuma Copper Co., Nacozari, Sonora, Mexico, as division engineer and foreman, and from 1933 to 1935 he was

mine boss for the Fresnillo Co., Fresnillo, Zacatécas. Mr. Stover was superintendent from 1935 to 1938 for Republican Mining & Metal Co., Wadley, San Luis Potosí. He was also with Cía. Minera y Refinadora Mexicana Ltd., Wadley, San Luis Potosí, and with San Francisco Mines of Mexico Ltd., San Francisco del Oro, Chihuahua, Mexico.

MEMBERSHIP

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Total AIME membership on June 30, 1955 was 22,910; in addition 1890 Student Associates were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

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Coming Events

Aug. 27, AIME, Adirondack Section, Tupper Lake Country Club, Tupper Lake, N. Y. John F. Meyers, speaker. Golf tournament.

Sept. 1, AIME, Utah Uranium Subsection, 7:30 pm, Arches Cafe, Moab.

Sept. 8-9, Western Area Development Conference, sponsored by Stanford Research Institute, American Industrial Development Council, and Pacific Northwest Trade Assn., Multnomah Hotel, Portland, Ore.

Sept. 16, AIME Oregon Section, Burns Restaurant, Portland, Ore.

Sept. 24, AIME, Adirondack Section, Plattsburg Elks Club, New York. Speaker from General Electric Co. on labor relations.

Sept. 25-28, American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N. Y.

Sept. 26-30, Atomic Industrial Forum, trade fair, Sheraton-Park Hotel, Washington, D. C.

Sept. 28-Oct. 1, Southwest International Mining Assn. and New Mexico Mining Assn., joint meeting, El Paso, Texas.

Oct. 2-5, AIME MGGD fall meeting and Black Hills regional meeting of the Ind. Min. Div., Rapid City, S. D.

Oct. 6-8, AIME, Minerals Beneficiation Div., fall meeting, **Rocky Mountain Minerals Conference,** Salt Lake City.

Oct. 10-13, American Mining Congress, Metal Mining—Industrial Minerals Convention, Las Vegas, Nev.

Oct. 10-13, Fourth National Clay Conference, sponsored by the Clay Minerals Committee of the National Research Council, Pennsylvania State University, University Park, Pa.

Oct. 13-15, Annual Drilling Symposium, School of Mines and Metallurgy and the Center for Continuation Study, University of Minnesota, Minneapolis.

Oct. 14-15, National Society of Professional Engineers, fall meeting, Peabody Hotel, Memphis, Tenn.

Oct. 17-18, Conference on Mining Research, U. S. Bureau of Mines and Missouri School of Mines, Rolla, Mo.

Oct. 17-19, AIME, IMD, fall meeting, Adelphia Hotel, Philadelphia.

Oct. 17-21, National Safety Congress and Exposition, Conrad Hilton, Congress, Morrison, and La Salle Hotels, Chicago.

Oct. 19-20, ASME, AIME, fuels conference, Neil House, Columbus, Ohio.

Oct. 24-26, Sixth National Conference on Standards, sponsored by National Bureau of Standards and American Standards Assn., Sheraton-Park Hotel, Washington, D. C.

Oct. 27-29, AIME, Industrial Minerals Div., fall meeting, Hotel Charlotte, Charlotte, N. C.

Nov. 4, AIME, NOHC, Pittsburgh Local Sections, off-the-record meeting, Pittsburgh.

Nov. 13-18, American Society of Mechanical Engineers, Diamond Jubilee annual meeting, Congress, Hilton, and Blackstone Hotels, Chicago.

Dec. 10-16, Atomic Exposition, Public Auditorium, Cleveland. Sponsored by the American Institute of Chemical Engineers in conjunction with the Joint Nuclear Congress.

Feb. 20-23, 1956, AIME, Annual Meeting, Statler and New Yorker Hotels, New York.

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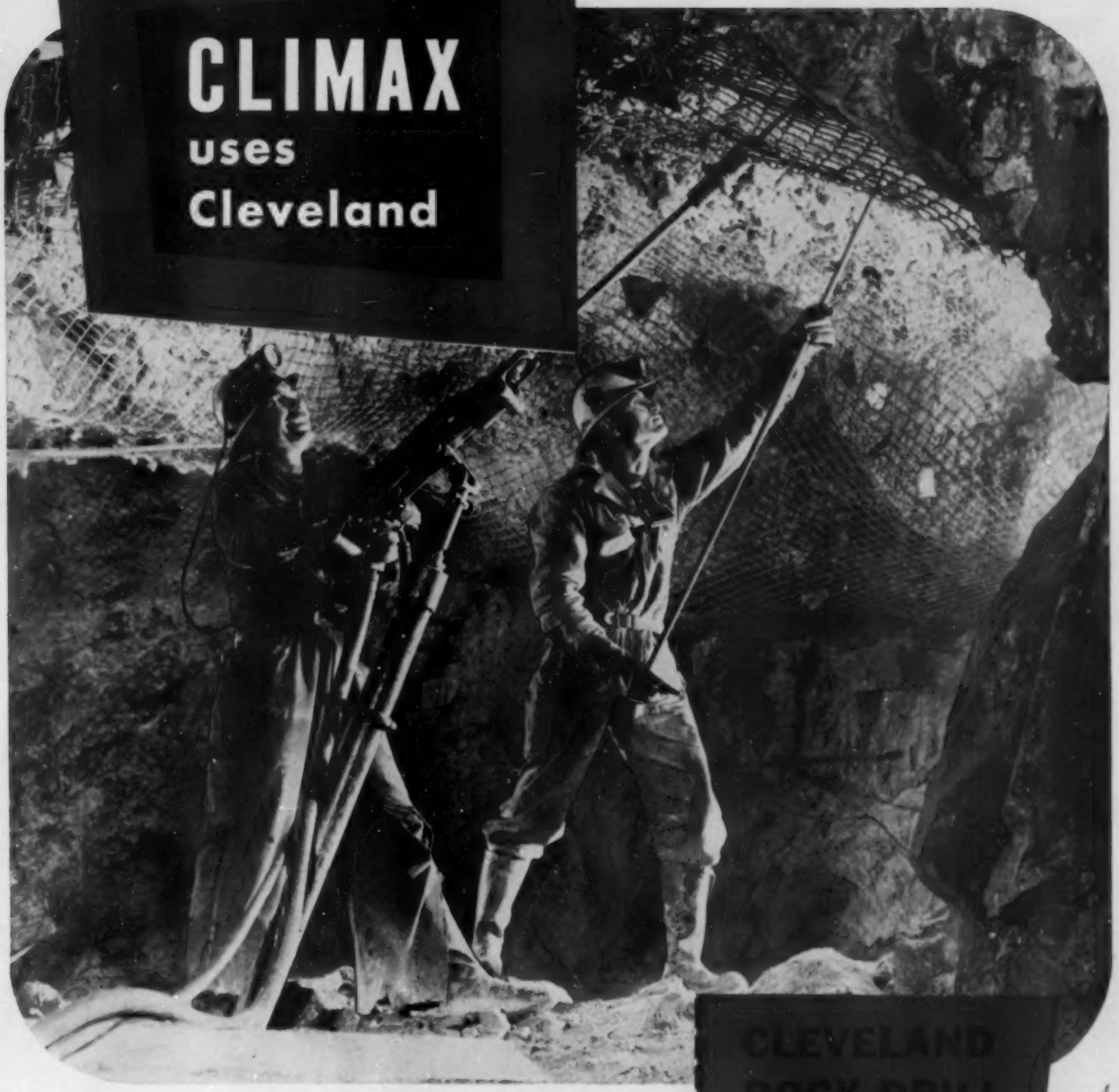

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